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REVIEW OF SELECTED MARINE MUNICIPAL OUTFALLS IN BRITISH COLUMBIA

Regional Program Report 84-11

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ENVIRONMENT CANADA
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC AND YUKON REGION

REVIEW OF SELECTED MARINE MUNICIPAL OUTFALLS IN BRITISH COLUMBIA

Regional Program Report 84-11

By

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August 1984

ABSTRACT

Receiving environment monitoring programme data collected between 1970 and December 1983 has been collated and interpreted for selected marine municipal outfalls in British Columbia. Of interest were 1) nutrient levels in receiving waters; 2) metals and organic contaminant levels in water, sediment and biota and 3) sublethal effects of contaminants on commercially important marine organisms. Data reported by numerous authors has been summarized and reviewed with respect to comparative literature.

Other than the pre-extension McMicking Point discharges, the quantities of nutrients, metals and organic contaminants from the marine municipal outfalls considered herein do not appear to pose a threat to the marine environment. There was evidence of elevated mercury levels in pre-extension McMicking Point effluent, sediment and biota and an impact on fauna in the pre-extension outfall area. Sublethal studies of marine organisms have not been conducted in the monitoring programmes reviewed, however, they may be useful in future monitoring studies.

RÉSUMÉ

Des données de programmes de surveillance pour l'environnement récepteur recueillies entre 1970 et décembre 1983 ont été comparées et interprétées pour une sélection d'émissaires marins municipaux en Colombie Britannique. Les points d'intérêt étaient: 1) les niveaux d'éléments nutritifs dans les eaux réceptrices; 2) les niveaux de métaux et de contaminants organiques dans l'eau, les sédiments et le milieu biotique; 3) les effets sous-léthaux des contaminants sur les organismes marins ayant une importance commerciale. Les données rapportées par de nombreux auteurs ont été résumées et passées en revue par rapport à la littérature comparée.

A l'exception de l'effluent de McMicking Point avant extension, les quantités d'éléments nutritifs, de métaux et de contaminants organiques déversées par les émissaires marins municipaux considérés ici ne semblent pas présenter une menace pour l'environnement marin. Dans l'effluent de McMicking Point avant extension, les sédiments et le milieu biotique, il y avait évidence de niveaux élevés de mercure, ainsi que d'un impact sur la faune dans la région de l'émissaire avant extension. Aucune étude sous-léthale d'organismes marins n'a été menée parmi les programmes de surveillance passés en revue; cependant ces études pourraient être utiles das les programmes futurs.

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CONCLUSIONS

1. Receiving water data presented in this review indicates there is no nutrient enrichment in marine waters adjacent to the marine municipal outfalls. Therefore, the application of sensitive methods of detection and measurement of eutrophication which are available is not yet warranted.

2. Receiving water data collection carried out for the municipal marine outfalls considered in this review has been sporadic and the recording accuracy of some information is questionable.

3. Effluent, sediment and mussel soft tissue data indicated levels of mercury in the receiving environment of the pre-extended McMicking Point municipal outfall was elevated above other areas in southern British Columbia receiving domestic waste. In this case it would have been appropriate to examine the sublethal effects on major indicator species to determine more precisely the effects on the organisms and on the local ecosystem.

4. Results from the McMicking Point monitoring programmes suggested there was an impact on the diversity of fauna in the vicinity of the pre-extended outfall.

5. Mean levels of mercury, lead, copper and cadmium in shellfish collected adjacent to municipal outfalls considered in this review were above mean levels in molluscs obtained from waters close to urban and industrial areas in southern British Columbia.

1.0 INTRODUCTION

The impact of domestic discharges on the British Columbia marine environment has been studied at a variety of locations along the mainland and Vancouver Island coastlines. Oceanographic studies carried out in the mid 1960's helped outline the environmental principles underlying waste disposal to the sea (Waldichuk, 1968). Early programmes were initiated in 1965 to assess the affect of Victoria's raw sewage discharges (Associated Engineering Services Ltd., 1966). Since that time, Provincial guidelines concerning the collection of marine environmental data have become more stringent resulting in a continuation of monitoring in Victoria and initiation of monitoring programmes in other coastal areas.

The purpose of this report was to collate and interpret particular data collected during monitoring programmes carried out from 1970 to December 1983. The following selected marine municipal outfalls, located within the districts illustrated in Figure 1, have been reviewed.

Capital Regional District - Macaulay Point
- Clover Point
- McMicking Point
- Finnerty Cove
- Sidney

District of Nanaimo - Five Finger Island
- French Creek

Campbell River
Powell River
Prince Rupert
Greater Vancouver Regional District - Lions Gate

These outfalls are further characterized in Table 1.

Data sources include Federal (Environmental Protection Service), Provincial (Waste Management Branch) and municipal (including Regional Districts) agencies as well as Universities and consultants.

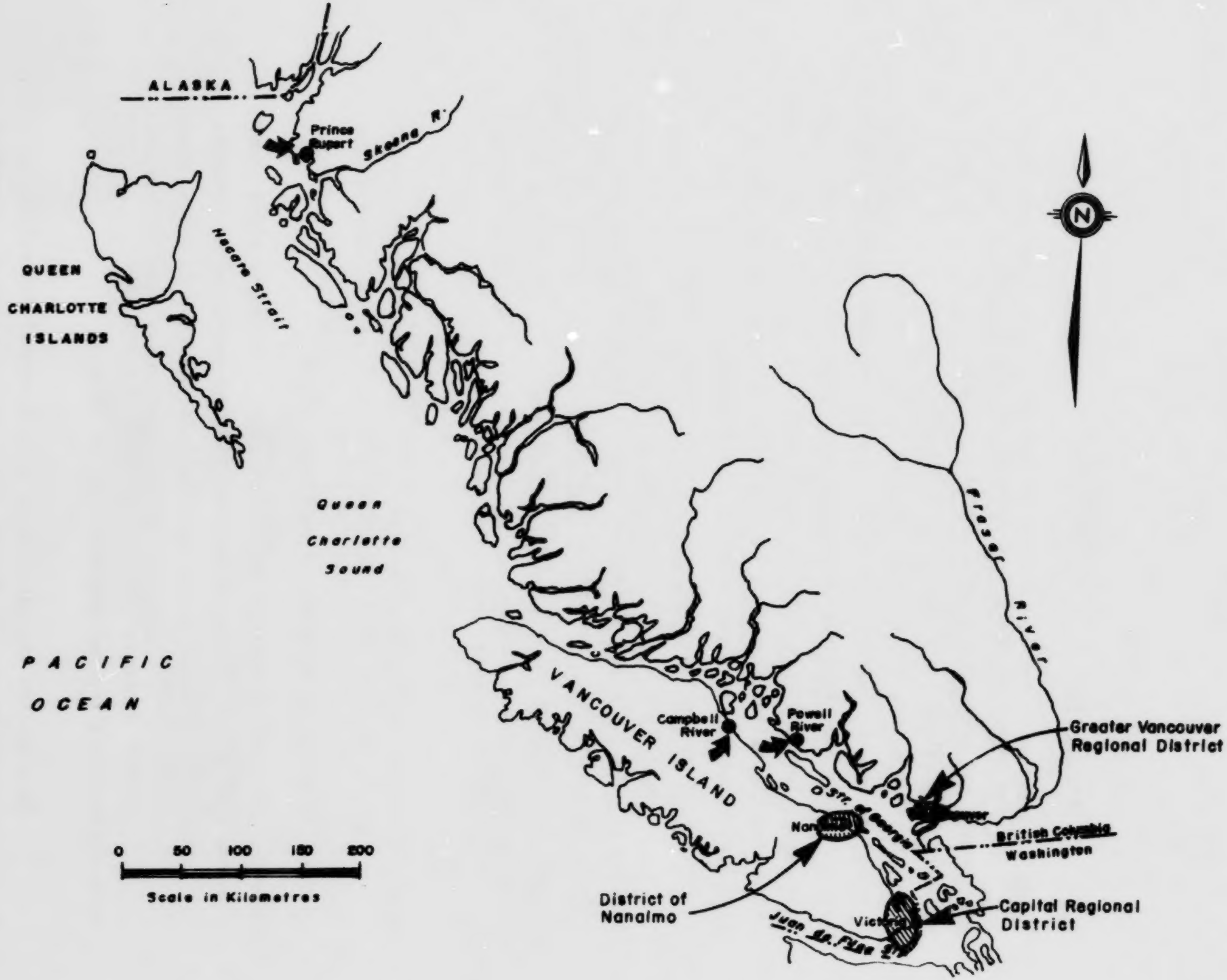

FIGURE I LOCATION MAP SHOWING STUDY AREAS

TABLE 1 SUMMARY OF PERMITS AND OUTFALL AND DIFFUSER DIMENSIONS OF SELECTED MARINE MUNICIPAL OUTFALLS IN BRITISH COLUMBIA

SITE	DATE	PERMIT NO.	PERMIT FLOWS m^3/day	DIAMETER (mm)	TOTAL LENGTH (m)	LENGTH (m) (LWL)	DEPTH (m)	TREATMENT	CONFIGURATION	DIFFUSER LENGTH (m)	DIFFUSER DEPTH (m)	DISCHARGE	POPULATION* SERVICED
Macaulay Point	17/Dec/75	PE-270	54,552	914	1717	1669.7	60.8	Comminution only	Tapered and ported at 508 mm centres	153	61	Juan De Fuca Strait	75,258
Clover Point	20/Jun/73	PE-1877	63,000	1067	1106	932	57.6	Comminution only	Straight ported at 3500 mm centres	196	67	Juan De Fuca Strait 18 of 54 ports open	
McMicking Point				1050	232	222	19.5	Comminution only	Single port 150 mm diameter		19.5	Enterprise Channel	
Finnerty Cove	04/Jun/68 20/Oct/81	PE-231	6,800 13,000	610	634	466	15.5	Comminution Primary Chlorination	Single port 61 mm diameter		15.5	Haro Strait	
Sidney	07/Oct/77	PE-136	5,900	457	662	524	11.5	Activated sludge Roto-strainer	Tapered and ported 76 mm diameter at 4.6 m centres	85.3	12.3	Sidney Channel	8,452
Five Finger Island		PE-338	average 27,274					Primary with Chlorination	"Y" shaped. Each arm 9.15 m long. 7.62 cm diameter ports every 1.83 m. Total no. ports is 104	2030	70	Georgia Strait	49,347
French Creek	May/75	PE-4200				2438.4	61	Secondary				Georgia Strait	7,000
Campbell River	21/Dec/64	PE-109	average 6818 as of 24/09/73	304.8		182.9	11.0	Clarifier, Grit removal, Activated sludge, Aerobic Digester	No diffuser			N. Georgia Strait Discovery Passage	16,411
	May/74	PE-109		533.4		115.8	6.9		No diffuser				
Powell River Westview	24/Jun/63	PE-73	average 5454	610	518			Barminuter Activated sludge extended aeration	No diffuser			Malaspina Strait	13,306
Powell River* Wildwood	12/Mar/66	PE-118	718	200	350 150 m below low tide		7	Chlorination Aerated lagoon Stabilizing pond	No diffuser			Malaspina Strait	

Continued...

TABLE 1 SUMMARY OF PERMITS AND OUTFALL AND DIFFUSER DIMENSIONS OF MAJOR MARINE MUNICIPAL OUTFALLS IN BRITISH COLUMBIA (Continued)

SITE	DATE	PERMIT No.	PERMIT FLOWS m^3/day	DIAMETER (mm)	TOTAL LENGTH (m)	LENGTH (m) (LWL)	DEPTH (m)	TREATMENT	CONFIGURATION	DIFFUSER LENGTH (m)	DIFFUSER DEPTH (m)	DISCHARGE	POPULATION SERVICED
Powell River Town Site	10/Jan/67	PE-171	average 6818	1270	305			Mechanical screens Hige rate activated sludge	No diffuser			Malaspina Strait	
Prince Rupert Outfall I	10/Sep/80	PE-5672-01	17,000	610		392	64	Comminution				Prince Rupert Harbour	16,786
Outfall G	10/Sep/80	PE-5577-02	4,500	400		32	18	None				Prince Rupert Harbour	
Outfall H	10/Sep/80	PE-5577-03	394,000	1,200		46	24	None				Prince Rupert Harbour	
Outfall J	10/Sep/80	PE-5577-04	11,200	400		107	26	None				Prince Rupert Harbour	
Outfall L	10/Sep/80	PE-5577-05	5,700	450		180	52	Comminution				Prince Rupert Harbour	
Outfall K	10/Sep/80	PE-5577-06	5,900	300		35	21	None				Prince Rupert Harbour	
Outfall A	11/Dec/80	PE-5577-07	27,700			50	21	None				Prince Rupert Harbour	
Outfall B	11/Dec/80	PE-5577-08	16,200			560	45	Comminution				Prince Rupert Harbour	
Outfall C	11/Dec/80	PE-5577-09	35,500			50	21	None				Prince Rupert Harbour	
Lions Gate	17/Feb/59	PE-30	102,000 as of 22/Feb/79									Burrard Inlet	

*Outfall dimensions are those under tender

Distance from the shoreline at mean sea level

‡Source: Statistics Canada. Estimations of Oct. 1983 populations based on 1981 census

The majority of data concerning concentrations of metals in water, sediment and biota plus water quality nutrient data has been presented according to sampling date and data source in Appendices I-IV. Tables summarizing the remaining nutrient and metal data have been placed appropriately throughout the text along with tables presenting organic contaminant contents of sediment and biota. The large quantity of nutrient and metal data stored by the Provincial government has been edited such that monitoring data cited has been collected from shoreline and offshore sites common to University and consultant reports.

Monitoring programme results have been grouped according to the listed individual outfalls. Conclusions made by authors who reported nutrient, metal and organic data have been reviewed. Their comments regarding the affects of pollutants on the composition of resident species and aesthetic impacts have been mentioned. In an attempt to present a thorough assessment of outfall areas, oceanographic conditions affecting dilution and dispersion of sewage effluent have been noted. Coliform levels in receiving waters have been considered as they helped complete the environmental assessment and the bacteria is the only universally used parameter for assessing the quality of marine receiving environments.

Discussion of the impact of sewage discharges on the marine environment of British Columbia has been based on comparisons made with monitoring programmes conducted at municipal outfalls whose receiving environments are similar to those of British Columbia.

2.0 MONITORING PROGRAM RESULTS

2.1 Macaulay Point

The downtown area of Victoria has been serviced by the Macaulay Point sewage outfall since 1913. In 1970, the Capital Regional District (CRD) was granted Discharge Permit No. 270, allowing the Macaulay Point beach sewer to be replaced by a marine outfall which discharges effluent from a 1870 m outfall at a depth of 61 m. Outfall dimensions and sewage treatment particulars are presented in Table 1.

The Macaulay Point diffuser terminates in the Strait of Juan de Fuca where thorough tidal mixing of fresh water flows from the Fraser River act as dispersal agents for the sewage effluent. Tidal velocities parallel to the shore have been recorded to run as high as 0.61 msec^{-1} (Balch et al, 1976).

The CRD is responsible for fulfilling the requirements of Permit No. 270. In compliance with the permit, an external body of experts proposed a monitoring program for the outfall receiving area. A team of scientists from the University of Victoria initiated monitoring fifteen months prior to the outfall completion date of August 1971, and continued sampling for a post discharge period of fifteen months.

Sampling sites routinely used in Macaulay Point surveys range from shoreline sites (S1-S5) and near shoreline sites (K1-K8) to receiving water sites (W1-W9) (See Figure 2). Wo is a non-fixed sampling station whose proximity to the diffuser locates the approximate position of the surface effluent field. Control stations J1 and J2 are located 8 and 16 km offshore (Figure 3).

The CRD outlined the Macaulay Point 15 month pre- and post-discharge monitoring program in three reports which were followed by nine quarterly data reports (Balch et al, 1976). Raw nutrient data collected during the Macaulay Point outfall monitoring program from 1970 to 1972 was collated by Balch et al (1973) who reported the aims, methods, results and conclusions of the monitoring program.

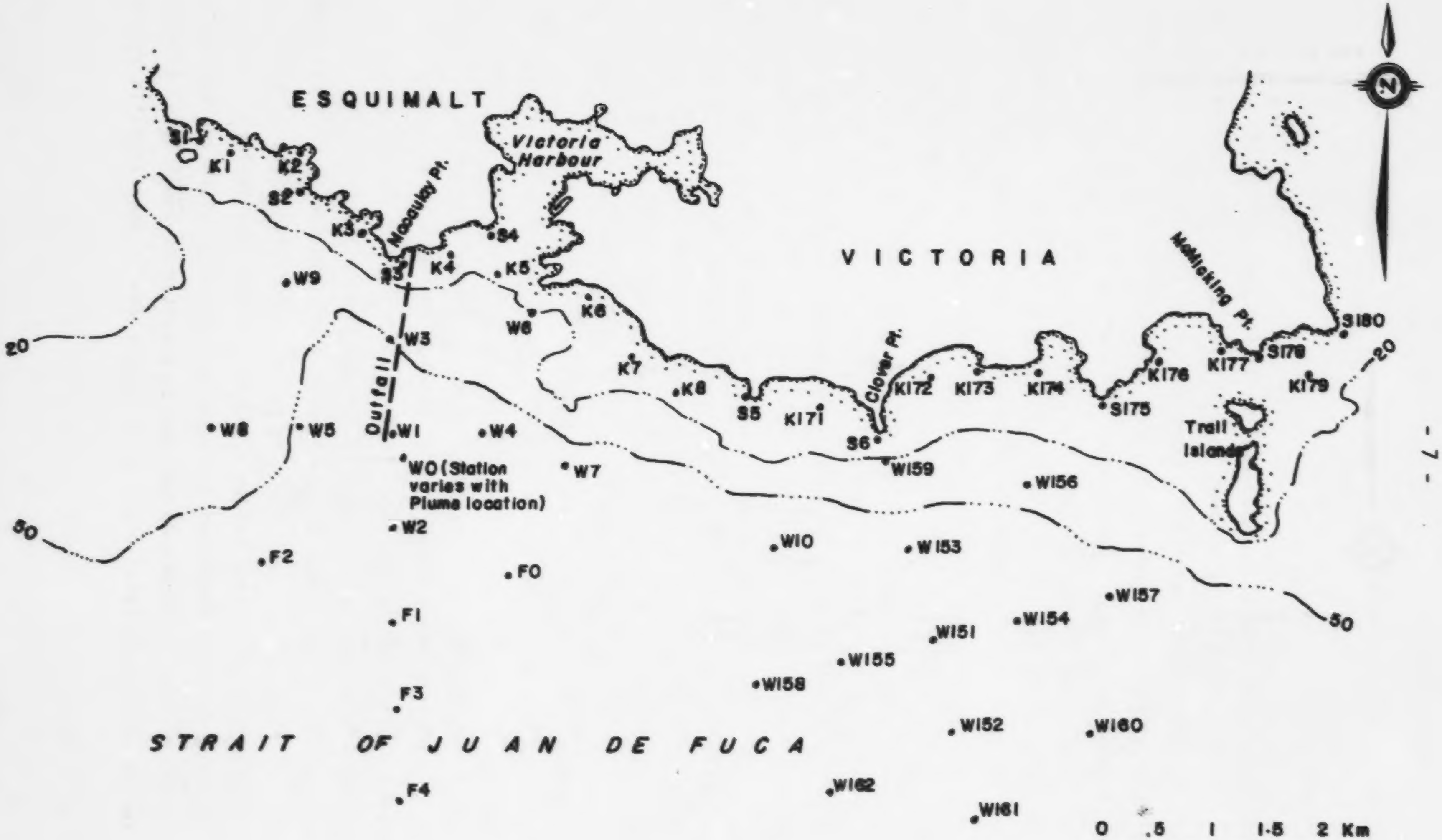

FIGURE 2 LOCATION OF SAMPLING STATIONS FOR MONITORING OF THE MACAULAY POINT AND CLOVER POINT MUNICIPAL OUTFALLS (Reference: Vassos 1982a)

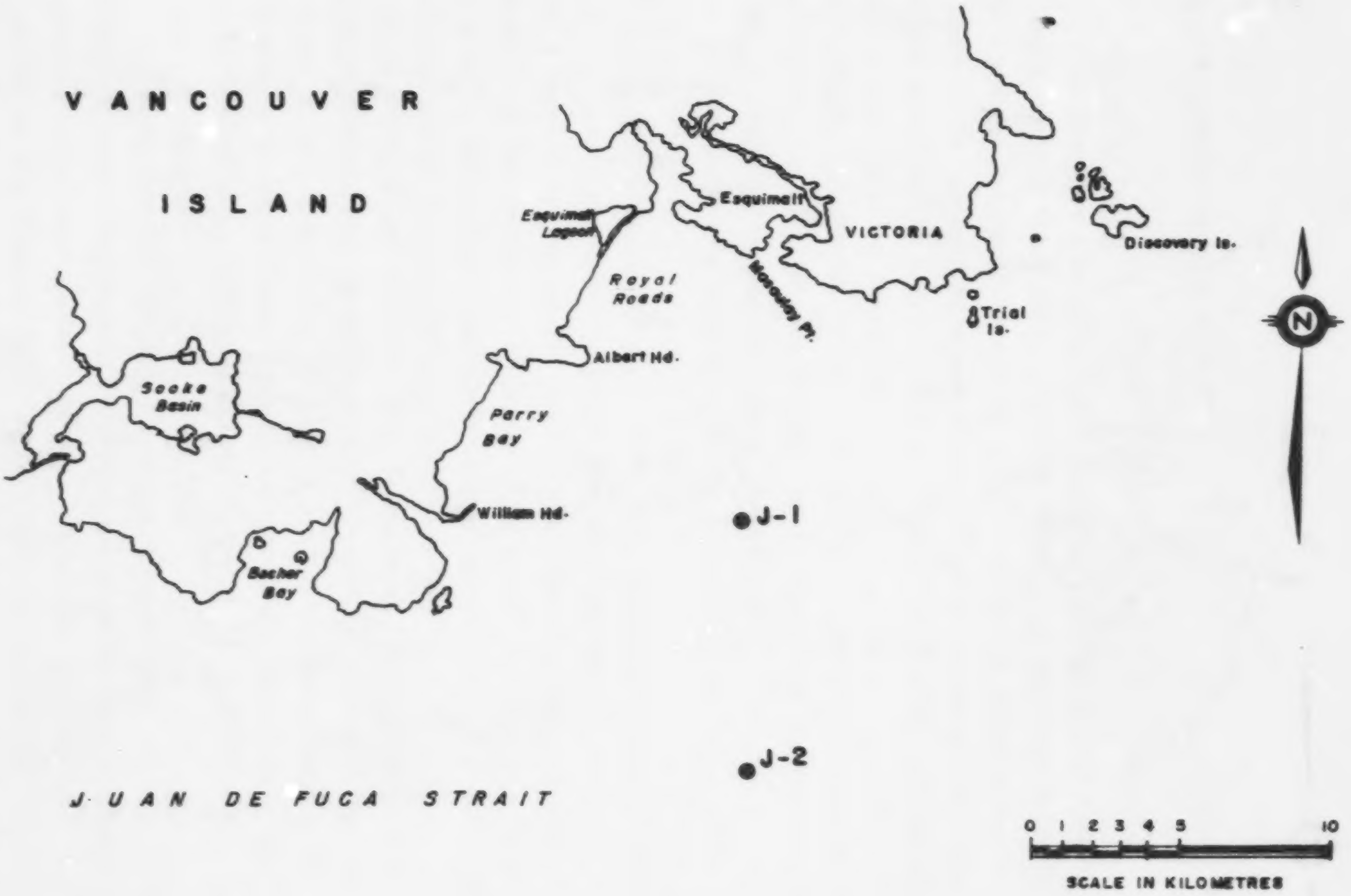

FIGURE 3 OFFSHORE SAMPLING STATIONS FOR MONITORING OF THE MACAULAY POINT MUNICIPAL OUTFALL

Major findings resulting from monitoring were reported by Balch et al (1976). Statistical analysis of routine water quality data determined that the following parameters indicated the presence of an effluent field: total and fecal coliforms, ammonia, phosphate, nitrite, Secchi depth and Forel colour. Nitrate levels did not give indication of the position of an effluent plume, but had a great influence on phytoplankton productivity and were therefore included in the program (Balch et al, 1976). The fifteen month pre-discharge and post-discharge nutrient levels were recorded in graphs according to monthly samples. Data extrapolated from the graphs is summarized in Appendix I. Sediment samples in the extended outfall area indicate the number and diversity of species was not affected. However, a shift in community composition and an increase in biomass were noted by Balch et al (1973 and 1976).

Vassos (1982a) presented CRD monitoring data in four volumes. Volumes II, III and IV contain raw and statistical data which was collected by the CRD as required by Permit No. 270. Data contained within these volumes was retrieved from the collection of water quality data recorded on the water quality data computer storage and retrieval system of the British Columbia Ministry of Environment (EQUIS).

CRD Marine Monitoring Data Volume I (Vassos, 1982a) summarizes the findings of a review of the CRD's data carried out by the University of Victoria. Nutrient data collected from 1973 to 1979 by the CRD was presented as monthly means for pooled stations (Vassos, 1982a). From this, it was concluded that seasonal variation in nutrient levels could not be attributed to the Macaulay Point municipal sewage outfall (Vassos, 1982a). Nutrient enrichment was not evident. Total and fecal coliforms were the only parameters which demonstrated a sewage outfall effect on the offshore sampling stations.

Further analysis of the CRD's marine monitoring programme suggested the Macaulay Point discharge did not cause the high average ammonia level found at stations W1 and S3. A source of ammonia other than sewage effluent near S3 was suspected as rapid tidal dispersion allows little nutrient concentrations resulting from effluent outflow (Hoff, 1981). The possiblity of frequency sampling errors influencing the ammonia concentrations was minimal; acceptable uniform confidence levels for stations W1 to W9 and S1 to S9 (Figure 2) were confirmed by Vassos (1980). Hoff (1981) concluded there was no evidence to indicate that parameters other than coliform data varied as a result of the Macaulay Point outfall. It was suggested that physical anomalies and ecological factors were responsible for non-linear time trends characteristic of nutrient data. Hoff (1981) arrived at these conclusions through significance tests applied to spatial patterns of nitrate, nitrite, phosphate and ammonia.

The Vancouver Island Regional Waste Management Branch (WMB) water quality computer data system (EQUIS) has been checked for completeness and accuracy for the period 1970-1979 (Hoff, 1981). Data gaps and errors were corrected by cooperation between the CRD and the WMB. The CRD collected marine water nutrient and coliform data which was forwarded to the WMB and together with WMB coliform data, was filed in EQUIS. The content of EQUIS for the period 1979-1982 has not been examined for completeness or accuracy.

Nutrient concentrations in Macaulay Point receiving waters and the derived statistical details retrieved from EQUIS cover sporadic sampling from 1970 to 1982 and are presented in Appendix IV. Appendix I presents summarized water nutrient data from four sources: Hoff (1981), EQUIS, Vassos (1982a) and the WMB. It should be recognized that Hoff (1981), EQUIS and Vassos (1982a) presented primarily 1976-1979 data collected from the same sources. Data collected by the WMB in 1981 does not show any sign of increase in nutrients in the receiving water of the Macaulay Point outfall between 1979 and 1981.

An Environmental Protection Service (EPS) survey of the Macaulay Point outfall (Goyette et al, unpublished) reported that the highest level of nutrients were found within approximately an 850 m radius of the diffuser terminus. Other than the noted nitrate concentration peaking at

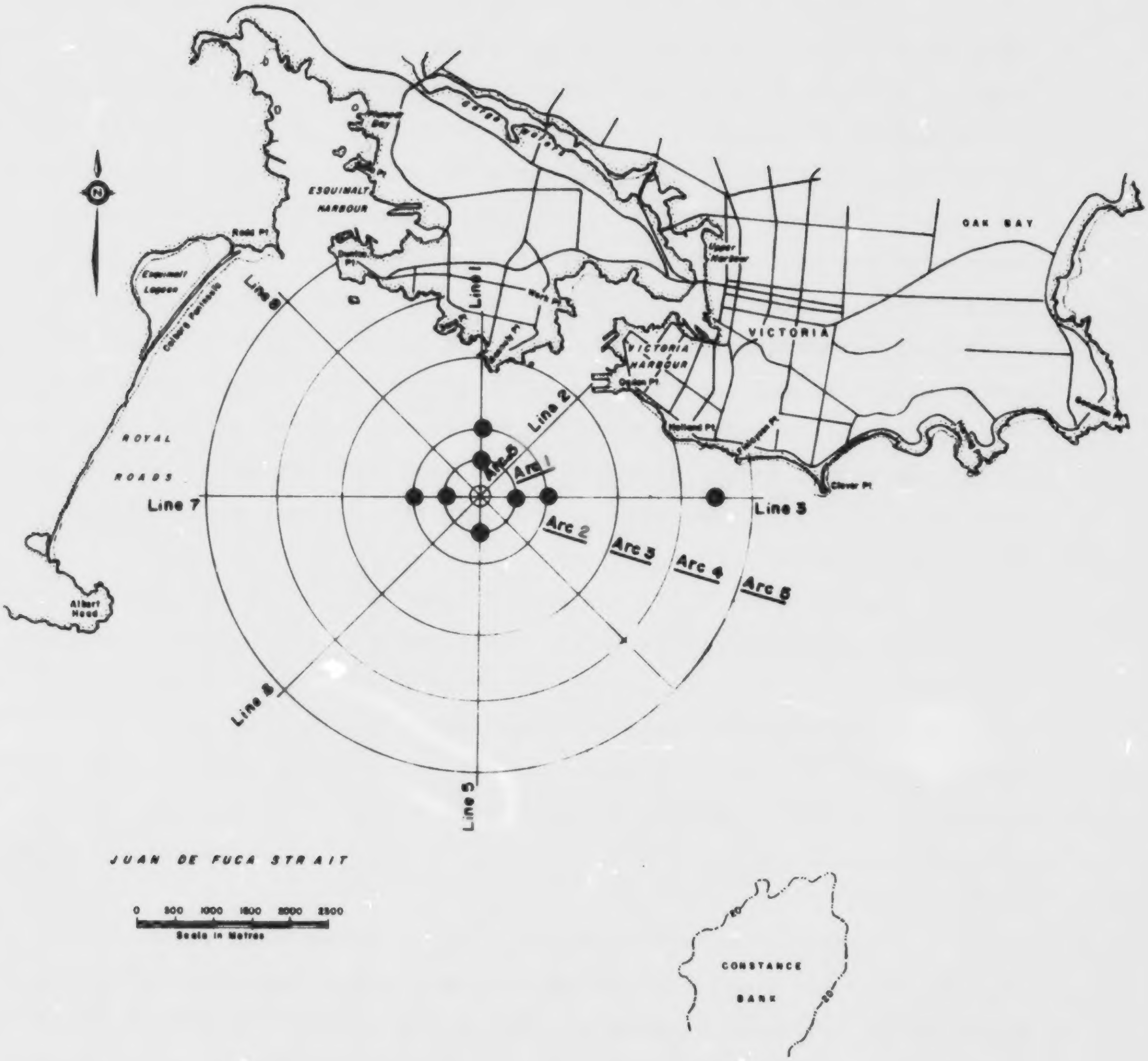

FIGURE 4 LOCATION OF MONITORING STATIONS FOR THE MACAULAY POINT MUNICIPAL OUTFALL (Reference: Goyette *et al* unpublished)

depths between 10 and 25 m, there were no other trends in the data. Goyette et al (unpublished) used nutrient sampling stations different from those in reports mentioned heretofore (Figure 4). This should be taken into account when comparing data collected by Goyette et al (unpublished) and other nutrient data.

Sediment samples in the Macaulay Point area were analyzed for heavy metal content by Goyette et al (unpublished) (Table 3). When compared with Victoria harbour metal concentrations, it was evident that contamination of sediments surrounding the outfall was attributable solely to the sewage discharge, and were not affected by sediment dispersion from the Victoria Harbour (Goyette et al, unpublished). Copper and lead concentrations indicated heavy metals accumulated in the area adjacent to the diffuser. A comparison of copper and lead levels between Macaulay Point samples and those taken in other regions of British Columbia's marine waters showed the Macaulay Point sediment to contain lower levels of copper and lead (Goyette et al, unpublished). Levels of accumulation of the two metals indicated there was no need for further monitoring of heavy metals until an increase in effluent flow is realized (Goyette et al, unpublished).

Analysis for PCB's and eleven other organochlorine contaminants in sediment taken from three sites within 500 m of the outfall, indicated there were not significant amounts of these contaminants introduced to the environment by the raw sewage effluent (Table 3) (Goyette et al, unpublished). It should be noted that pesticides were absent from sediment samples collected from 1970 to 1972 (Balch et al, 1973) and were below detection limits in the 1979 study (Goyette et al, unpublished), as shown in Table 3.

Observations made from dives in the submersible vessel Pisces IV, indicated the coarse and compacted substrate beneath the outfall supported an epifaunal community. Tissue analysis of the benthic fauna (Table 4) revealed that on the whole, low levels of metals were contained in invertebrate tissue. It was concluded there was no significant impact

TABLE 2 MACAULAY POINT: HEAVY METAL CONCENTRATIONS IN MARINE SEDIMENTS, JUNE AND NOVEMBER, 1979 (dry weight)

Reference: Goyette _et al_, unpublished

SAMPLING	COPPER (ppm) JUNE & NOV. 1979				LEAD (ppm) JUNE & NOV. 1979				ZINC (ppm) JUNE & NOV. 1979				CADMIUM (ppm) JUNE & NOV. 1979				MERCURY (ppm) JUNE & NOV. 1979			
STATION	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
Point of Discharge	3	24.1	14.1	35.1	3	36.8	12.2	69.2	3	67.0	61.3	70.6	3	1.27	< 1.20	1.35	3	0.334	0.267	0.385
Arc 0.5	9	34.4	11.1	36.8	9	22.0	< 9.8	43.0	9	65.5	51.1	78.0	9	1.36	< 1.20	1.66	9	0.541	0.167	0.950
Arc 1	9	15.8	11.6	21.8	9	15.5	< 9.8	23.7	9	58.0	46.4	69.4	9	1.23	< 1.20	1.30	9	0.403	0.232	0.745
Arc 2	7	13.6	9.0	23.9	7	11.7	< 9.8	17.4	7	54.3	43.7	71.5	7	< 1.20	< 1.20	< 1.20	7	0.340	0.166	0.459
Arc 4	4	10.3	9.1	11.1	4	9.8	< 9.7	9.8	4	49.9	40.4	58.5	4	< 1.20	< 1.20	< 1.20	4	0.342	0.258	0.457
Arc 5	3	13.6	11.9	14.7	3	11.2	< 9.9	13.5	3	57.0	47.0	66.0	3	1.21	< 1.20	1.25	3	0.322	0.161	0.432
Arc 6	4	15.9	14.4	18.5	4	11.5	10.7	12.2	4	64.1	58.6	72.9	4	1.28	< 1.20	1.40	4	0.480	0.313	0.574

TABLE 3 MACAULAY POINT: SEDIMENT PCBs AND OTHER CONTAMINANTS, JUNE 1979 (dry weight, ppm) Reference: Goyette *et al*, unpublished

STATION		PCBs	OTHER CONTAMINANTS*
LINE	ARC		
Macaulay Point Discharge		< 0.005	not detected
3	1	< 0.005	not detected
7	1	< 0.005	not detected

*Other contaminants include: chlorobenzenes, chlorophenols, DDT, DDD, DDE, aldrin, dieldrin, chlordanes, heptachlor, lindane endosulfans.

on benthic fauna by the sewage effluent (Goyette et al, unpublished). A Pisces IV dive carried out in May 1979, reports that the seabed opposite the diffuser consisted of black organic accumulation devoid of the epifaunal community typical of near outfall areas. The presence of large numbers of hermit crabs (Pagurus sp.) indicated both an increase in biomass and low community diversity which represents a pollution situation (Unpublished EPS data).

Specimens of the clam Compsomyax subdiaphana were collected from Macaulay Point sampling sites shown in Figure 2 for trace metal analysis by J.A.J. Thompson (1978). It was evident that sampling sites used by Thompson (see Figure 5) correspond with those in Figure 2. Table 4 presents the maximum, minimum and mean levels of copper, cadmium, lead, zinc and iron found in the soft tissue samples. The maximum zinc concentrations of 140.53 ug/g was atypical; the average zinc concentration in soft tissue was 55.40 ug/g (n=62).

2.2 Clover Point

A portion of downtown Victoria has been serviced by the Clover Point municipal outfall since 1894 (Ellis, 1976). Assessment studies by Ellis (1971a) and Ellis et al (1972) reported a decline in primary biological production in the effluent plume and a depression of shoreline algae beds around the Clover Point outfall. Both effects were related to sewage disposal. In attempting to improve the outfall area, a new 1302 m outfall discharging at a depth of 67 m was brought into operation in 1980 (Harms, 1981). The outfall dimensions and sewage treatment particulars are presented in Table 1.

The Clover Point diffuser terminates in the Strait of Juan de Fuca. Tidal mixing and fresh water flows act as dispersal agents (Balch et al, 1976) to dilute the sewage discharged from the diffuser. Turbulent mixing of tidal waters over a sill and around a headland caused vertical up-welling and horizontal eddying which resulted in a homogenous water column in the Clover Point area. Waldichuk (1983) reported a zone of

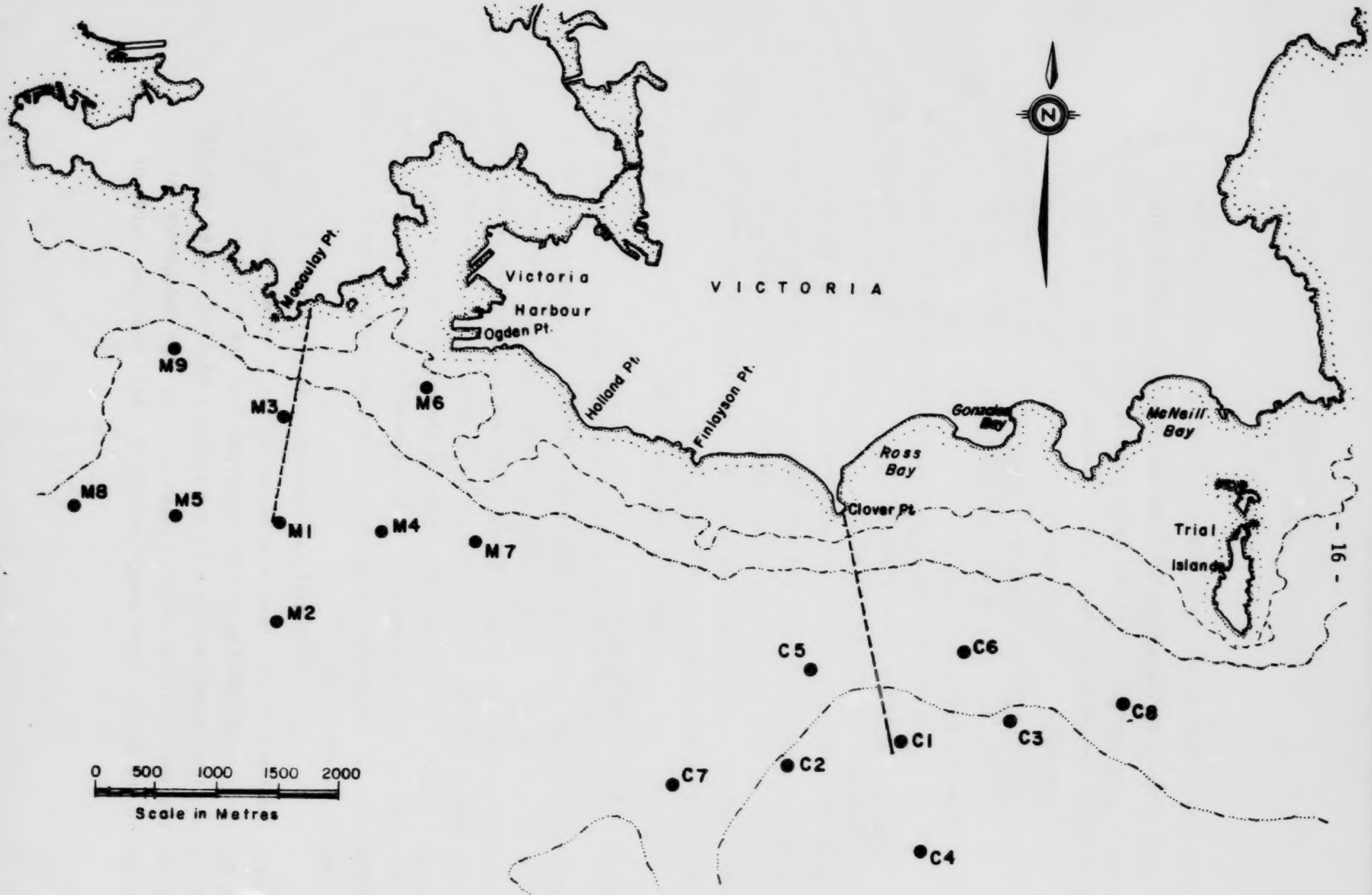

FIGURE 5 LOCATION OF SAMPLING STATIONS FOR MONITORING OF THE MACAULAY POINT AND CLOVER POINT MUNICIPAL OUTFALLS REPORTED BY J.A.J. THOMPSON

TABLE 4 MACAULAY POINT: TRACE METAL CONCENTRATIONS IN SOFT TISSUE (dry weight)

SAMPLING		CADMIUM (ppm)				IRON (ppm)				COPPER (ppm)				LEAD (ppm)				ZINC (ppm)				
STATION	SPECIES	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	DATA SOURCE
M1	*Compsomyax*	4	0.39	0.24	0.79	4	28.21	20.96	78.27	4	2.48	1.34	3.75	4	1.10	0.48	2.95	4	57.65	50.44	71.34	J.A.J. Thomson
M2	*subdiaphana*	9	0.61	0.28	2.46	7	141.74	35.42	236.17	9	5.06	0.014	13.66	8	2.98	0.48	11.07	7	56.88	37.57	73.98	1978 data
M3		10	0.97	0.06	2.17	9	166.74	55.00	274.04	10	7.10	0.014	14.38	10	1.93	0.45	5.39	10	59.93	33.33	140.53	
M5		12	0.88	0.07	2.13	10	160.13	21.49	440.13	12	6.70	0.73	18.76	12	1.74	0.48	3.76	12	57.66	37.09	105.89	
M6		2	0.50	0.42	0.57	2	57.67	32.67	82.67	2	2.13	1.95	2.31	2	1.40	1.23	1.56	2	69.18	51.02	87.33	
M8		10	0.43	0.05	2.10	7	364.98	33.23	1110.64	10	11.04	1.66	24.30	10	2.18	0.48	4.64	7	49.87	32.66	75.67	
M9		8	0.77	0.05	1.93	6	164.21	49.44	239.84	9	7.33	0.014	23.90	8	2.86	0.48	5.77	6	53.38	45.84	77.22	
							MERCURY (ppm)															
Line 7, Arc 1	Clam		2.79				0.200							1	5.29							Goyette *et al*, unpublished
Trawl no. 1	Ratfish/liver		0.058				< 0.149*							1	< 0.0096*							
	Flatfish/flesh with skin and bone		< 0.046				0.133							1	< 0.046							
Trawl no. 2	Ratfish/liver		0.035				< 0.145*								< 0.010*							
	Pink shrimp (whole)	10	1.810				0.160							10	< 0.048							
	Pink shrimp (no head)	10	0.088				0.236							10	< 0.049							

*Indicates wet weight concentration due to excessive oil in samples.

vigorous vertical mixing stretching from Boundary Pass to Juan de Fuca Strait. These sources of turbulence, while reducing the chance of stratification, could result in dilution of a rising effluent plume.

2.2.1 Pre-Extension Monitoring. CRD sampling of receiving waters commenced July 1976 as stipulated in an amendment to Discharge Permit No. 1877 which is dated December 17, 1975. All receiving water samples collected by the CRD were taken from sites displayed in Figures 2 and 6.[1] CRD sampling of receiving waters commenced July 1976 and continued until November 1979 (Vassos, 1982).

The majority of receiving water sampling done in the Clover Point area was carried out between 1976 and 1979, however, data recorded on EQUIS reaches as far back as 1971. Additional sampling sites were incorporated in the monitoring programme until 1978 when all Clover Point sites shown in Figure 2 and 5 were utilized. Nutrient concentrations in Clover Point receiving waters and statistical details retrieved from EQUIS and Vassos (1982a) are presented in Appendix IV and summarized in Appendix II.

The quality of the Clover Point receiving waters were similar to those of Macaulay Point: the mean monthly values of the nutrients recorded from stations S5, S6, S175, W10 and W151 to W158 were almost identical to those of the Macaulay offshore stations for the period from 1976 to 1979 (Hoff, 1981). It follows that the conclusions for the Clover Point marine monitoring programme were precisely the same as those for the Macaulay Point programme. That is, there was no evidence of nutrient enrichment and no time trends for the water qualtiy parameters could be attributed to either outfall (Vassos, 1982). This conclusion was reinforced by statistical analysis which indicated that spatial and temporal effects of nutrients were below the detection threshold and were therefore negligibly small for the waters in the Clover Point area (Hoff, 1981).

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[1] Due to confusion surrounding the identification of sampling locations assigned by various investigators to the Macaulay and Clover Point monitoring programs, both Figures 2 and 6 have been included in this report. It is recognized that considerable overlap exists between these two figures.

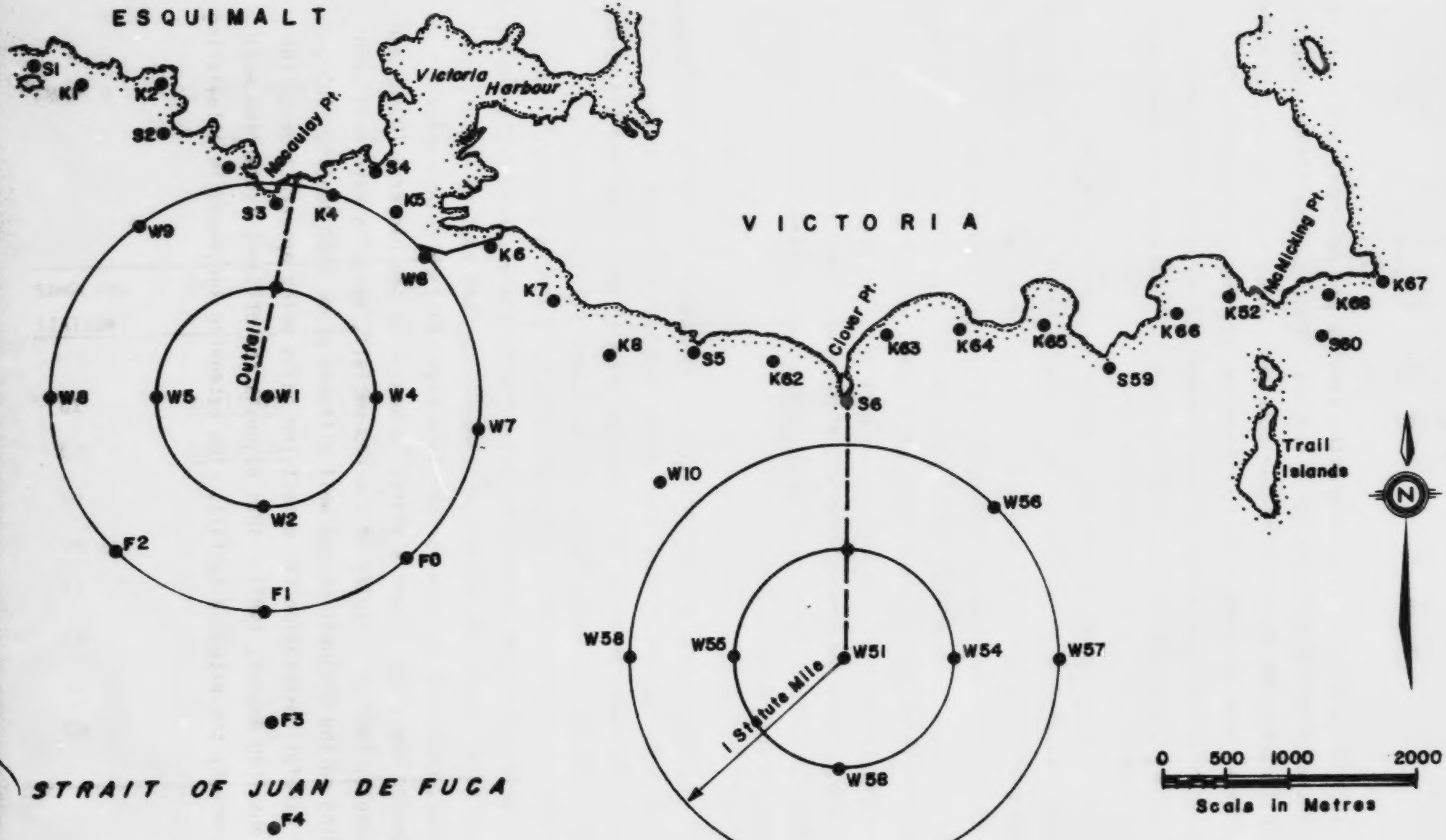

FIGURE 6 LOCATION OF SAMPLING STATIONS FOR MONITORING OF THE MACAULAY POINT AND CLOVER POINT MUNICIPAL OUTFALLS (Reference: Balch *et al* 1976)

Clover Point receiving water samples had generally lower coliform concentrations than Macaulay Point samples. However, the Clover Point shoreline stations exhibited higher coliform levels than the samples taken from sites west of Clover Point. Shoreline sources were suspected as causing high coliform concentrations (Vassos, 1982) which were common throughout the Clover Point and McMicking Point receiving environments (Hoff, 1981).

Upon request by the CRD, Dobrocky Seatech took benthic faunal and sediment samples from ten sites: W10 and W151 to W159 (Figure 2) in 1977. Results of the enumeration and identification of 18 benthic faunal samples and 20 particle-size analysis were listed by Byers and O'Connell (1982).

J.A.J. Thompson (1977), analyzed the soft tissue of the horse mussel Modiolus modiolus and found trace metal levels in concentrations presented in Table 5. Mussel samples were obtained from sites shown in Figure 6. Copper, cadmium, lead and zinc levels found in the Clover Point mussels were above those found in Compsomyax subdiaphana found in the Macaulay Point area.

2.2.2 Post-Extension Monitoring. An attempt to extend the Clover Point outfall in 1978 failed when strong tidal currents and weather-related disturbances broke the extension pipe (Brown, 1980) and triggered a debate over the extension length of the Clover Point outfall. A feasibility study resulted in construction of a 1302 m outfall (Harms, 1981) which succeeded in reducing shoreline coliform concentrations west of Clover Point (Byers and O'Connell, 1982). Stations east of Clover Point however, continued to show sporadically high coliform counts which suggested there was indeed a shoreline source of the bacteria (Byers and O'Connell, 1982). In spite of the new outfall, seagulls have been seen feeding on the effluent of the well diffused plume (CRD Report, 1983). Only careful observation can detect the gulls which appear close to the horizon (CRD Report, 1983). This suggests the effluent is carried well offshore by the extended outfall. The extension succeeded in alleviating

TABLE 5 CLOVER POINT: TRACE METAL CONCENTRATIONS IN SOFT TISSUE OF THE CLAM, *Modiolus modiolus* (dry weight)

Reference: J.A.J. Thompson, 1978

SAMPLING STATION	SPECIES	COPPER (ppm)		LEAD (ppm)		ZINC (ppm)		CADMIUM (ppm)		IRON (ppm)	
		1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
C1	*Modiolus*	166	105	37	5	1999	933	47	59	1684	479
C2	*modiolus*	112	105	23	8	1552	1364	78	41	755	386
C3		039	107	0	8	1015	797	11	27	446	326
C4		052	112	7	7	1091	746	13	29	446	326
C5		129	111	16	0	1987	904	25	38	573	247
C6		057	089	8	11	957	647	13	25	303	268
C7		036	083	21	21	603	728	12	26	181	267
C8		085		6		758		6		188	

the aesthetically unpleasing seagull flocks previously common to nearby, offshore areas.

Following the outfall extension, one set of Clover Point water quality data was submitted to the regional WMB by the CRD. The WMB nutrient data summarized in Appendix II was not included in the EQUIS records.

The latest amendment to Permit No. 1877 dated January 18, 1980 did not require the Permittee (the CRD) to carry out monitoring of the receiving environment and it appears there has not been any offshore monitoring since September 1982 (B. Warman, pers. comm.).

Vassos (1982b) examined pre- and post-extension coliform data for the area surrounding the Clover Point outfall. Data collected between April and November 1981 by the CRD Health and Engineering Departments indicated the outfall extension reduced coliform concentrations to within swimming standards on the shoreline west of Clover Point. Shoreline samples collected east of the outfall continued to have periodically high coliform counts (Vassos, 1982b).

Coliform data from samples collected at various depths at post-extension monitoring stations demonstrated that the effluent is generally well mixed throughout the water column. During periods of high temperatures, there was evidence of stratification. Included in the Clover Point outfall performance report (Vassos, 1982b) was a review of Hoff's (1980) post-extension monitoring programme recommendations.

Coliform monitoring of the new Clover Point outfall was carried out from April 6, 1981 to April 13, 1982. The coliform counts reported by Williams Sigma Consultants Ltd. (1982) were below the swimming water standard. CRD Health Department post-extension coliform samples exceeded the recreational contact standard. However, these samples were suspected to be influenced by shoreline sources. As stated by the Williams Sigma report (1982), the CRD Health Department coliform data gave evidence that the Clover Point outfall extension performed according to its design and permit criteria.

The CRD Greater Victoria East Coast Sewerage Study (1983) assessed the Clover Point sewage outfall and concluded that upgrading of the system was not necessary. This conclusion was reached by examination and subsequent assessment of the sewerage facilities, evaluation of performance information and from discussions held between the municipality and B.C. Ministry of the Environment WMB authorities.

2.3 McMicking Point

In 1913, a beach outfall was constructed at McMicking Point to service residents of Victoria and the Southern Saanich Peninsula. May 1982 marked the construction completion and operation of an extended 232 m outfall which discharged comminuted sewage into Enterprise Channel at a depth of 19.5 m (Bartlett et al, 1983).

Enterprise Channel was thought a suitable area for the discharge of municipal wastes as it was subject to tidal mixing, fresh water flows (Balch, 1976) and vertical mixing actions which were common to the Haro and Juan de Fuca Straits (Waldichuk, 1983). Tidal currents may be a stronger mixing component here than at other outfall locations; flood currents can be accelerated to speeds of around 2.5 m/sec. as they are squeezed through the narrows of Enterprise Channel (Thomson, 1981).

2.3.1 Pre-Extension Monitoring.

The impact of the disposal of domestic sewage on the McMicking Point shoreline and marine environments was conducted by Dr. Ellis (University of Victoria) under contract to the CRD. Pre-extension monitoring was the topic of Dr. Ellis's first four reports. Report No. 3 (Ellis, 1979a) reported results of both sewage bioassays and of a shoreline survey which indicated a normal shoreline ecosystem in the McMicking Point area. Eleven organic compounds from the EPA priority pollutants list were found in the sewage. Report numbers 1, 2, 3, 4 and 5 are noted in the reference section of this review.

Amongst the plethora of McMicking Point monitoring programme reports was a study of the local shoreline and sub-tidal ecosystems (Ellis and Emerson, 1979). The survey of shoreline species composition abundance and distribution gave evidence that the sewage outfall did not cause any significant changes in the species composition or distribution up to 1979 (Ellis and Emerson, 1979).

Bierheuzen (1982) sampled Fucus epifauna at the same sites as Ellis and Emerson (1979). Results recorded by Bierheuzen (1982) correspond with those of Ellis and Emerson (1979). That is, the effect of sewage on the epifaunal communities was small. It was noted that the diversity of species was slightly lower at the outfall than at sites further afield (Bierheuzen, 1982). Increase in the abundance of three epifaunal species was evident while the abundance of one species decreased. These trends correspond with those noted by Ellis and Emerson (1979). It was suggested that there was seasonal influence on the abundance of Fucus epifauanl species (Beirheuzen, 1982). The results of monitoring reported by Ellis and Emerson (1979) and Bierheuzen (1982) suggested there was a recognized impact on the epifauna within the vicinity of the pre-extended McMicking Point sewage outfall. Both studies noted that relatively few new species were found within 200 m of the outfall terminus.

Report #7 (Ellis, 1980a) revealed the contents of sewage released at the McMicking Point outfall contained detectable amounts of chlorinated hydrocarbons and four phthalate esters; two polychlorinated biphenyls (PCB's) were detected in minute amounts (0.04 and 0.16 ug/l). Cadmium, copper and lead levels in the comminuted sewage were generally lower than the provincial objectives for waste discharges from the mining industry (Ellis, 1980a). Iron, a substance not considered to be an EPA priority pollutant, was recorded at levels above the provincial objectives (Ellis, 1980a).

Further pre-extension monitoring of the receiving ecosystem indicated sewage flows had depressive effects in the immediate area of the McMicking Point outfall and minor, yet noteworthy effects within 200 m of the outfall pipe (Ellis, 1980a). Samples of Mytilus californianus were taken just west of the outfall and from two control sites (Figure 6). As

TABLE 6 MCMICKING POINT: CONCENTRATIONS OF TRACE METALS IN MUSSEL TISSUES (dry weight)
References: Brown, McFarland and Thompson, 1980
Ellis, 1980b

STATION IDENTIFICATION	COPPER (ppm)	CADMIUM (ppm)	LEAD (ppm)	ZINC (ppm)	MERCURY (ppb)
M1 (W. of Outfall) (M. californianus)	9.4	1.6	4.3	153	Average 201
M3 (control) (M. californianus)	7.9	3.5	ND	176	87
M3 (control) (M. edulis)	10.3	3.3	ND	221	155
NBS SRM 1577 (Bovine liver)					
SEAKEM Value*	172 ± 6	0.31 ± 0.02	ND	143 ± 1	954
NBS Certified Value	193	0.27	0.34	130	1100 ± 500

ND = below detection limit (detection limit for lead is 1.1 ppm)
*triplicate analysis

seen in Table 6, mercury and lead were found in the soft tissue of the outfall mussels in quantities markedly above the level in control mussels. The metal contents of the mussel soft tissue reported by Ellis (1980b) had higher levels of mercury and lower concentrations of copper than the soft tissue contents of mussels as reported by Can Test Ltd. (Table 7). Sewage was suspected of being the source of lead as well as lindane and methoxychlor which were detected in M. californianus soft tissue (Ellis 1980b).

The conclusions made by Ellis (1980a and b) incorporate major findings from several studies (McFarland, 1979; McFarland, 1980; Brown, McFarland and Thompson, 1980). Brown, McFarland and Thompson (1980) sampled sediments 200-300 m from the outfall and analyzed them for organic contaminants (Table 8). Concentrations of PCB's and phthalate esters were elevated over those at the control site as were levels of lead, copper and mercury found in sediment samples (Table 9). Comparison between M. edulis and M. californianus from outfall sites and control sites revealed considerable tissue and organ degeneration of the organisms collected in the vicinity of the shoreline outfall. Table 10 shows levels of methoxychlor and the PCB, Arochlor 1254 in mussel samples taken adjacent to the outfall were well above the amounts found in control specimens. The cause of elevated metal concentrations in sediment samples and the histopathological observations could not be attributed solely to the McMicking Point sewage outfall (Brown, McFarland and Thompson, 1980). Contributions from alternate sources (such as the atmosphere, storm and industrial runoff) were not identified. It is worth noting that levels of organics found in sediments and mussels were above those in the sewage. This suggests contaminants originating from municipal sewage were being concentrated by the bivalves and may have contributed to the degeneration of mussel tissue (Ellis and Gee, 1981).

Green and VanZinderen Bakker (1981) found the total organic contaminants in M. californianus were highest in the specimens collected close to the outfall. Organic contaminant levels were low in mussels taken 7 km from the outfall.

TABLE 7 MCMICKING POINT: CONCENTRATIONS OF TRACE METALS IN WATER AND TISSUE

Reference: Can Test Ltd., Vancouver

21/Nov/78 - plasma spectrographic analysis results

	SAMPLE TYPE		
METAL	WATER (ppm)	WATER (ppm)	TISSUE (ppm)
Copper	0.15	0.001	18.8
Cadmium	0.002	0.001	3.10
Lead	0.039	0.001	3.15
Zinc	0.15	0.001	152.0
Mercury	0.0007	0.0002	0.25

TABLE 8 MCMICKING POINT: CONCENTRATIONS OF SELECTED ORGANIC CONTAMINANTS DETECTED IN SEDIMENT SAMPLES

Reference: Brown, McFarland and Thompson, 1980

CONCENTRATION (ppb)

CONTAMINANTS	(W. of Outfall) S1			(E. of Outfall) S2			(Control) S3		
	a	b	ave*	a	b	ave	a	b	ave
Diethyl phthalate	ND	ND	ND	ND	0.8	0.4	ND	0.6	0.3
Di-n-butyl phthalate	22	12	17	750	160	160	ND	ND	ND
Butyl benzyl phthalate	NQ	NQ	NQ**	ND	38	19	ND	ND	ND
Bis (2-ethylhexyl) phthalate	265	1970	1120	793	1230	1010	36	132	84
Hexachlorobenzene	(5.0)	2.33	3.7	0.45	0.39	0.42	0.08	0.07	0.08
Lindane	ND	1.75	0.88	0.86	0.38	0.62	ND	0.34	0.17
DDE (o,p'-;pp'-)	1.4	1.3	1.4	1.5	2.5	2.0	ND	ND	ND
Methoxychlor	ND	ND	ND	2.8	3.5	3.2	ND	ND	ND
Arochlor 1242	tr	tr	tr	tr	tr	tr	ND	ND	ND
Arochlor 1254	8.5	4.8	6.7	8.1	6.5	7.3	ND	ND	ND

*ave = average of two duplicate samples, a and b.

**NQ = not quantitated due to interfering peaks. Butyl benzyl phthalate in S1 samples less than 10 ppb.

TABLE 9 MCMICKING POINT: CONCENTRATIONS OF TRACE METALS IN SEDIMENT SAMPLES (dry weight)
Reference: Brown, McFarland and Thompson, 1980

CONCENTRATION (ppm)

STATION IDENTIFICATION	COPPER (ppm)	CADMIUM (ppm)	LEAD (ppm)	ZINC (ppm)	MERCURY (ppb)
					average
S1 (W. of Outfall)	32.8	0.14	4.5	58.2	465
S2 (E. of Outfall)	36.6	0.12	6.6	62.5	>1000
S3 (Control)	19.0	0.15	1.2	53.8	45
NBS SRM 1645 (River sediment)					
SEAKEM Value*	119 ± 6	9.9 ± 0.5	819 ± 24	1970 ± 90	954
NBS Certified Value	109 ± 19	10.2 ± 1.5	714 ± 28	1720 ± 169	1100 ± 500

*Triplicate analyses

TABLE 10 MCMICKING POINT: ORGANIC CONTAMINANTS IN MUSSEL SAMPLES: Comparison of 1980 and 1981 Analyses (*Mytilus californianus*)

Reference: This table summarizes data presented by Ellis (1980b) and Ellis and Dempsey (1982) in McMicking Point Reports #8 and #12.

1980 data is adapted from Brown and Thompson, 1980. 1981 data is adapted from Green and VanZinderen Bakker, 1981.

CONTAMINANT	CONCENTRATION (dry weight, ppb)			
	ADJACENT TO OUTFALL (Station 4)		CONTROL (Station 16)	
	1980	1981	1980	1981
Phthalate Esters				
Diethyl phthalate	ND	ND	6	1
Di-N-butyl phthalate	49	11	ND	ND
Butyl benzl phthalate	ND	tr	ND	ND
Bis (2-ethylhexyl) phthalate	1270	63	ND	ND
Chlorinated Pesticides				
Hexachlorobenzene	1.8	0.2	1.8	tr
Lindane	1.3	0.4	ND	tr
DDE (p,p'+p,p')	18	22.5	12	5.6
Methyoxychlor	59	16	ND	6
PCB's				
Arochlor 1242	tr	ND	ND	ND
Arochlor 1254	84	127	32	ND

Table 11 presents the results of sediment analysis for organic carbon content. The highest percentage of organic carbon of 1.36 did not suggest there was excessive build up of organics in the shoreline sediment of McMicking Point (M. Pomeroy, pers. comm.).

Several sources (EPS Memorandum, 1977; Dempsey and Kashuro, 1981) noted that the waters from Harling Point to Gonzales Point, including the Trial Island area, is a rearing ground for salmon and groundfish. A fish fin-rot survey carried out in December 1980 revealed pacific herring, bay pipefish, sculpins and the one flounder caught did not show any sign of fin rot (Legg and Dempsey, 1981). Further beach seine samples collected in April 1981 by Dempsey (1981), revealed none of the fish had physical abnormalities common to the inhabitants of sewage outfall areas (Ellis, 1982).

McMicking report #11 (Ellis, 1981) reported evidence of sewage discharge along the beaches adjacent to McMicking Point. Fecal coliform levels in samples taken from sites seen in Figures 7 and 8 reached as high as 44,700 colonies/100 ml (Ellis, 1981) which was substantially above the recreational contact standard of 200 colonies/100 ml. High fecal coliform levels resulted in the closure of beaches in the area.

In summary, the sewage discharge from the McMicking Point shoreline outfall contributed to elevated contaminant levels in shellfish and sediment adjacent to the outfall terminus. The diversity of faunal species was lower in the outfall area than at control sites while fin-rot was not detectable. Coliform monitoring suggested there were sewage eddies in Enterprise channel.

2.3.2 Post-Extension Monitoring. After the construction of the outfall extension at McMicking Point (Aug. 1980-May 1981), coliform monitoring was carried out by Williams Sigma Consultants Ltd. (1983). The consultants report points out that winter fecal coliform levels above the recreational contact standard persisted in 1982. The main source of the bacteria was suspected as being the McMicking Point sewage outfall (Williams Sigma, 1983).

TABLE 11 MCMICKING POINT: ORGANIC CARBON CONTENT OF SEDIMENTS

Reference: Brown, McFarland and Thompson, 1980

SAMPLE NO.	LOCATION	% ORGANIC CARBON*
S1a**	W. of Outfall	0.90
S1b	"	1.06
S2a	E. of Outfall	0.85
S2b	"	1.36
S3a	Control Site	0.79
S3b	"	0.78

*on a dry weight basis

**samples designated a and b are duplicates obtained at the same station

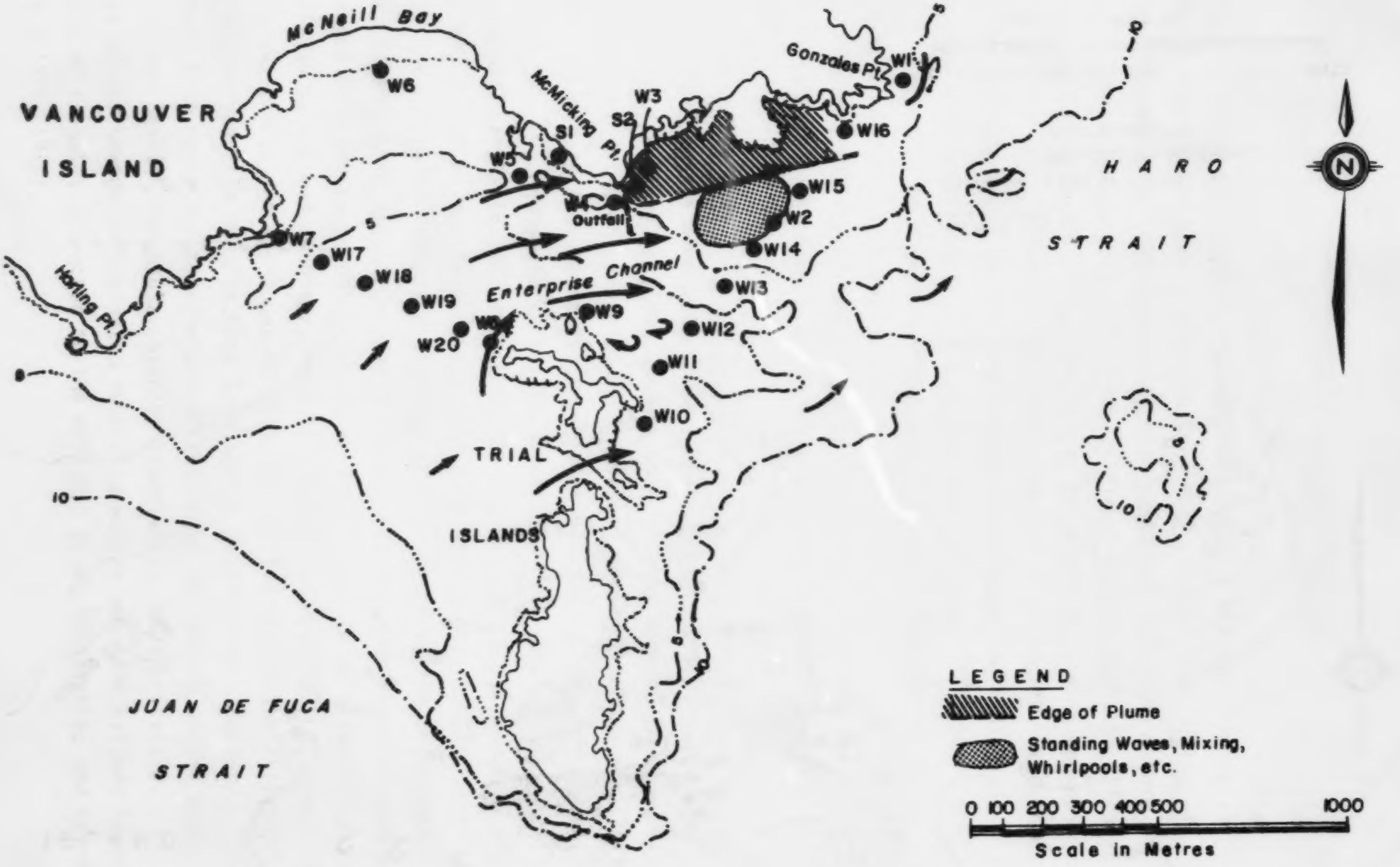

FIGURE 7 PRE-EXTENSION SAMPLING STATIONS AND GENERAL SURFACE CURRENT AND EDDY PATTERNS NEAR McMICKING POINT AT FLOOD TIDE (Reference: Ellis 1981)

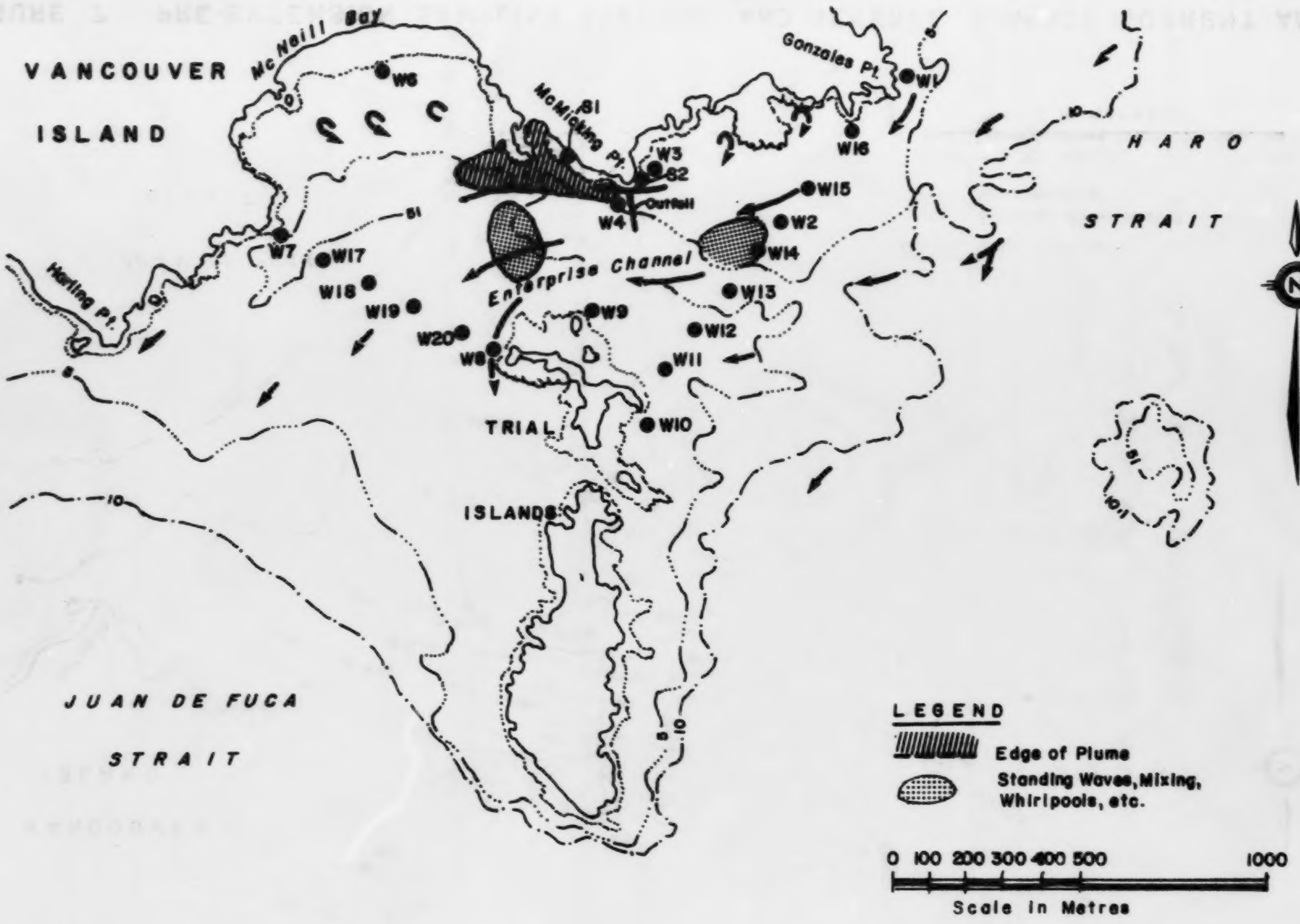

FIGURE 8 PRE-EXTENSION SAMPLING STATIONS AND GENERAL SURFACE CURRENT AND EDDY PATTERNS NEAR McMICKING POINT AT EBB TIDE (Reference: Ellis, 1981)

Coliform data implies the extended outfall did not alleviate unfavourable shoreline sewage eddy patterns (CRD, 1983). Monitoring of the outfall receiving environment has been suspended until the future of the outfall has been decided (CRD, 1983). Visual evidence of the effluent plume was marked by beach litter and flocks of seagulls feeding on what residents claim was a visible plume (CRD, 1983). It should be noted that the extended outfall did improve the impoverished shoreline biologial populations which extended 5-10 m down the beach (Ellis, 1984).

Proposals to divert sewage flows from the McMicking Point outfall to a more suitable marine outfall have been presented by the CRD (1983). The possibility of the Clover Point outfall servicing the Victoria and East Saanich populations is presently under consideration.

2.4 Finnerty Cove

The Finnerty Cove outfall was constructed in 1961 to serve the municipality of Eastern Saanich. Permit No. 231 was amended in June, 1978 to allow comminuted sewage to be discharged through the 466 m outfall into Haro Strait at a depth of 15.5 m (Figure 9) (See Table 1 for outfall dimensions). A recent study states the sewage outfall serviced approximately 31,600 people in 1982 with peak dry and wet weather flows of 19,400 m^3/day and 26,400 m^3/day respectively (Stanley Associates, 1982).

A series of reports evaluating the marine receiving environment of the Finnerty Cove discharge gave evidence that the quantities of sewage discharged into the surrounding waters were too large to be effectively assimilated by the marine environment (Ellis, 1976; Kay, 1980; Stanley Associates, 1982). It was apparent that the low quality of the effluent being discharged from the Finnerty Cove sewage outfall was a factor responsible in part, for the closure of shellfish harvesting on the east coast of the Saanich Peninsula (Stanley Associates, 1982). Visible effects of the sewage contaminated receiving waters was made evident by he presence of seagulls attracted to the effluent plume, floatables and beach litter (Ellis, 1976).

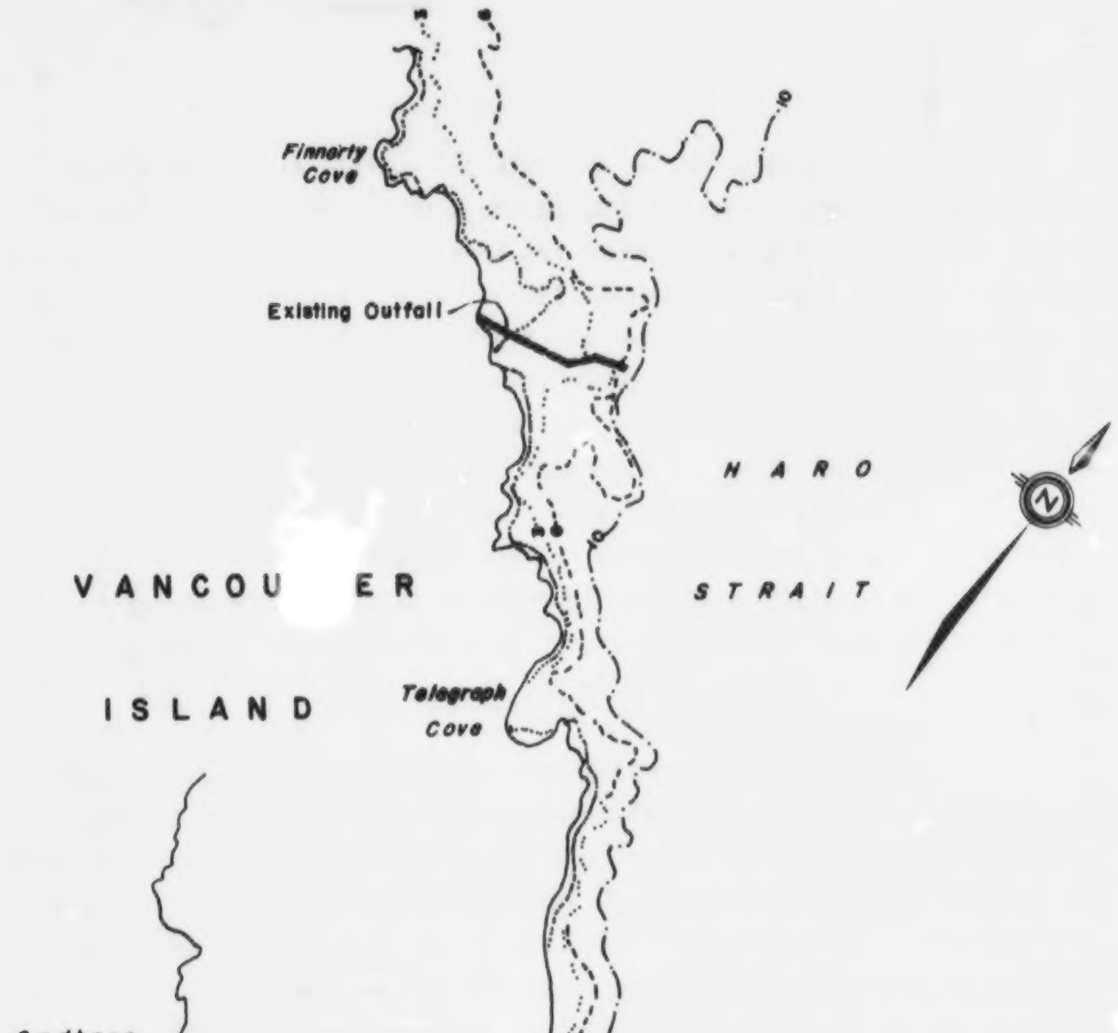

FIGURE 9 LOCATION OF THE FINNERTY COVE MUNICIPAL OUTFALL

Early studies noted occasionally high coliform counts (above 1000 MPN/100 ml) within half a mile and adjacent to the Finnerty Cove outfall (Ellis, 1971b). During the period of sampling, chlorination was in progress. Strong water mixing in the area kept coliforms, salinities and nutrients mixed to the extent that they located neither an effluent plume nor a thermocline (Ellis, 1971b and c). Intertidal and subtidal studies suggested that little biological deterioration occurred near the outfall (Ellis, 1971c). Coon (1972) concluded that the Finnerty Cove effluent had little effect on the structure and vertical distribution of intertidal algae communities.

In 1971, local observers became concerned over the occasional onshore arrival of waste which possibly originated from the Finnerty Cove sewage outfall (Ellis, 1976). Water quality tests established continuous mixing and no stratification because of strong tidal currents. The surfacing plume was subject to occasional onshore winds which, in combination with slack water and a high discharge rate, could reach the shoreline. It was suggested that an outfall extension would move the point of discharge to a depth where there would be weakened onshore forces influencing the effluent plume (Ellis, 1976).

Coliform data was recorded on EQUIS for the period from January 1, 1965 to December 22, 1982. A sample obtained at the surface in the outfall boil contained 0.04 mg/l of both copper and zinc. This sample was the only record of any data other than coliform counts presented on EQUIS.

A bacteriological survey was conducted in waters off the east coast of the Saanich Peninsula in November, 1979 and for a brief period in January, 1980 by EPS. It was found that the nine marine stations between Gordon Head and Telegraph Cove exceeded the shellfish growing standard (Kay, 1980). The Finnerty Cove sewage outfall, with a mean effluent fecal coliform concentration of 4.96×10^6/100 ml, contributed an estimated 92% of the fecal coliform loading to the study area (Kay, 1980). Visual evidence of sewage discharge on the beach south of the outfall was noted. The study resulted in shellfish closure of the Finnerty Cove area, from Gordon Head to 10 Mile Point in 1980.

Stanley Associates (1982) found insufficient information to assess the impact of seepage from malfunctioning septic tank fields, storm drain outfalls and overflow from sewage lift staions on near shore water quality. High coliform numbers (17 x 10^6 to 9400 x 10^6 MPN/100 ml) were found by the examination of effluent samples (Stanley Associates, 1982). These figures plus coliform counts noted from studies previously mentioned, helped persuade the engineering study to recommend improvement schemes combining outfall extension with varying degrees of sewage treatment.

Copper, cadmium and zinc found in shellfish tissue was suspected of originating from Finnerty Cove sewage. As reported by Stanley Associates (1982), samples taken in Telegraph Cove and at the outfall terminus had high levels of copper and cadmium in relation to McMicking Point samples (Table 12). It should be noted that the typing error found in Finnerty Cove Outfall Study, Volume I (Stanley Associates, 1982) which reports shellfish tissue metal levels in ppb has been correctly reported in ppm in Table 12 of this report. The PCB's Arochlor 1254 and 1242 were found in tissues of molluscs analyzed by Stanley Associates (1982). Results showed bioaccumulation of the PCB's to 10.4 and 12.8 ppb which compared to trace quantities and 127 ppb found in McMicking Point samples (Stanley Associates, 1982). The PCB concentrations in shellfish tissues from Finnerty and Telegraph Cove were said to be of little concern as they were below the acceptable levels for human consumption of 100 ppb.

TABLE 12 FINNERTY COVE: METAL CONCENTRATIONS IN SHELLFISH TISSUE
Reference: Stanley Associates, 1982

	FINNERTY COVE Outfall Terminus (ppm)	Telegraph Cove (ppm)	McMicking Point (ppm)	Recommended* Limit Freshwater Criteria
copper	55 - 57	5.9 - 90	9.0 - 9.4	none
cadmium	7.2 - 16	0.9 - 1.3	1.6 - 2.3	none
lead	0.42 - .54	0.76 - 0.94	1.6 - 4.3	10
zinc	845 - 915	96 - 103	125 - 153	none
mercury	.22 - .34	.25 - 1.75	0.2 - .46	0.5

*Criteria for saltwater receiving environment have not been established.

The only observable ecological effect of the Finnerty Cove sewage discharge on the marine environment was an enrichment of biological life, particularly of bivalves in the area of discharge (Stanley Associates, 1982). This was considered a positive rather than a negative effect on the marine ecology (Stanley Associates, 1982). There was evidence of organic matter accumulation at the end of the outfall and sediment deposition was very noticeable at depths of 20 m in the area of the outfall. Paper and plastics were common, apparently passing intact through the comminution process (Stanley Associates, 1982).

It should be noted that the Department of Fisheries and Oceans considered the Finnerty Cove area to be an important salmonid rearing ground (EPS Memorandum, 1982). Salmonids are susceptible to chlorine residues, heavy metals and other priority pollutants which, according to Stanley Associates (1982), were contained in sewage discharged at Finnerty Cove. A geoduck survey suggested there were commercially harvestable stocks in the Finnerty-Arbutus Cove area (Marine Resources Branch, Province of British Columbia, 1978).

Included in the Finnerty Cove Outfall Study by Stanley Associates (1982), was a thorough review of the physical oceanography of the area. Currents affecting the sewage discharge impinge on the Telegraph Cove shoreline approximately 40% of the time with a travel time of less than one hour from the outfall to the nearshore waters of Telegraph Cove (Stanley Associates, 1982). This result substantiated the conclusion of a flourescent dye and drift card study undertaken by Dobrocky Seatech in 1979 (Buckingham, 1979).

Large differences between south and east coast water quality data suggest the Fraser River influences the Haro Strait waters (Vassos, 1982). Higher temperatures, lower salinities and lower nitrate values were observed along the east coast (Vassos, 1982).

2.5 Sidney and East Coast Saanich Peninsula

Three sewage treatment plants located on the east coast of the Saanich Peninsula service residents of the area. Prior to 1966, three shoreline outfalls serviced the Sidney area (Barlott *et al*, 1983). In 1971, the CRD was authorized to construct an activated sludge treatment plant and a single outfall to replace the shoreline outfalls. The municipality of North Saanich did not combine with Sidney to utilize the sewage treatment plant. Amendment to Permit No. 136 in October 1977 authorized expansion of the treatment plant and construction of an outfall extension which operated with the old outfall acting as a bypass. A collection and treatment system was constructed in 1974 at Bazan Bay to service residents of North Saanich. The Central Saanich treatment plant was constructed in 1973 and expanded in 1982 as it was operating beyond its capacity in the late 1970's (Barlott *et al*, 1983). Storm drains located along the east coast of the Saanich Peninsula discharged waste

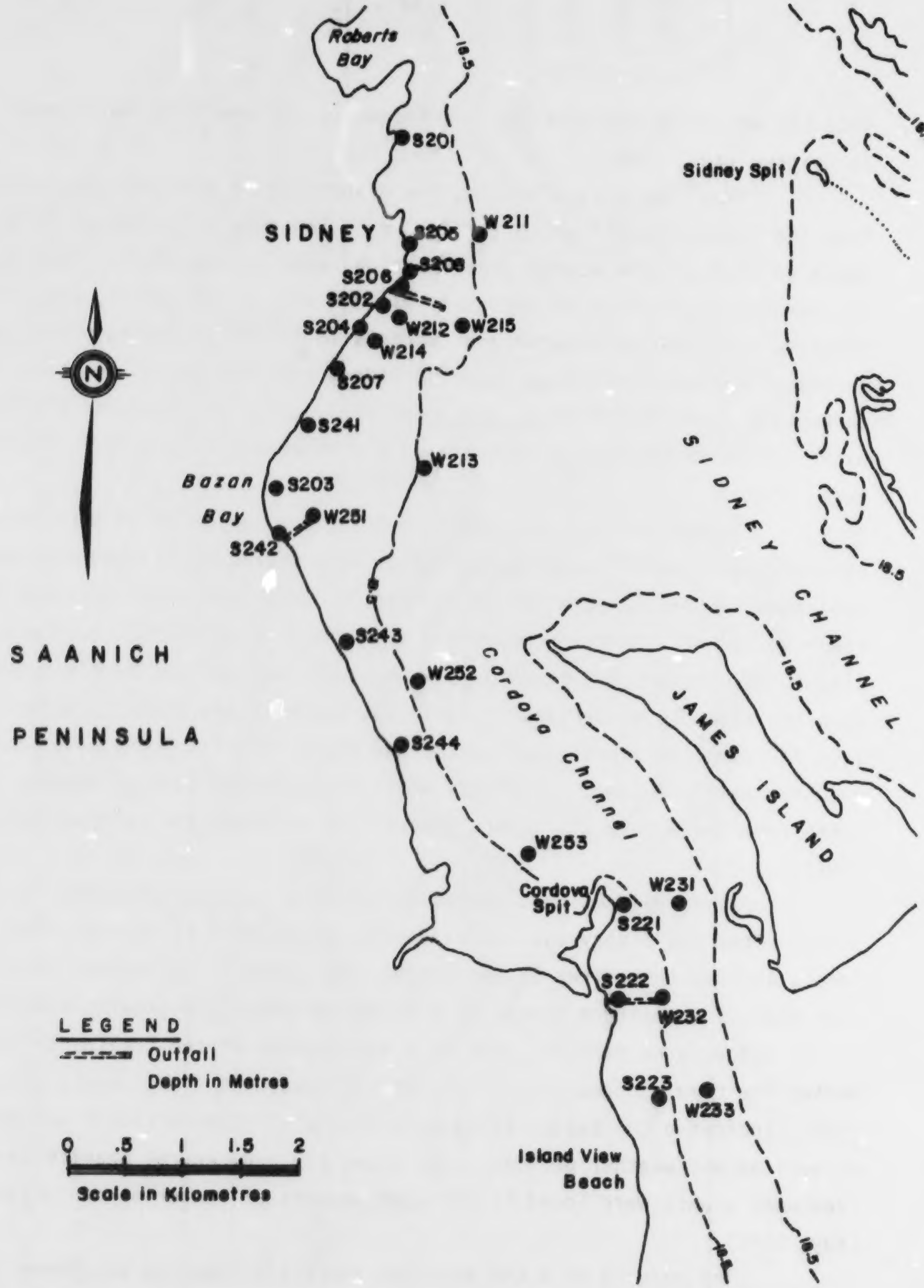

FIGURE 10 LOCATION OF MONITORING STATIONS FOR THE EAST COAST OF SAANICH PENINSULA (Reference: Hoff, 1981)

into the marine environment but the frequency and amount of waste expelled is unknown (Kay, 1980).

Tidal currents affecting the dispersion of effluent discharged from the Sidney outfall which is 747.3 m in length and discharges at a depth of 12.3 m, were weaker than the high velocity currents of Haro Strait but reached peaks of up to approximately 2.0 m/sec. (Thompson, 1981). The relative contribution of wind and currents to the total mixing effect was unclear. However, waters surrounding Sidney were influenced by strong currents of Haro Strait (L.F. Giovando, pers. comm.). It appears the water column in the Sidney Channel was a homogenous mixture (L.F. Giovando, pers. comm.).

Sidney and Central Saanich outfall monitoring sites were established in 1973. Bazan Bay stations were introduced to the monitoring programme in 1977 (Figure 10) (Hoff, 1981). Total and fecal coliform data reported by Hoff (1981) corresponded with the data on EQUIS. Nutrient data found on the EQUIS file for six of the Sidney outfall receiving water sampling sites is summarized in Table 13. Details are found in Appendix IV. All sampling sites other than those noted in this report have been used for coliform sampling. Heavy metal analysis was done on samples taken from the Sidney clarifiers the results of which are recorded on EQUIS.

It is evident that shoreline coliform counts diminished for a period after the Sidney outfall extension but climbed to unacceptable levels shortly thereafter (Vassos, 1982; Kay, 1980). Kay (1980) noted that shoreline coliform counts were above the shellfish growing standard in the Sidney area partially due to a malfunction of the treatment plant during the time of sampling. A history of treatment plant upsets (Kay, 1980), indicated the bypass released coarsely strained effluent during dry as well as wet weather periods. The Bazan Bay and Central Saanich sewage treatment plants were found to be major sources of bacterial contamination (Kay, 1980).

The results of a CRD directed shoreline sampling programme suggest major contributions to high coliform levels in receiving waters

TABLE 13 SIDNEY: WATER QUALITY NUTRIENT DATA

Maximum, Minimim and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

Reference: EQUIS

SAMPLING		AMMONIA (ppm)				NITRITE (ppm)				ORTHOPHOSPHATE (ppm)			
STATION	DEPTH (m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
W210	0	1	.0199	.0199	.0199	1	.0034	.0034	.0034	1	.0631	.0631	.0631
W211	0	14	.0188	.0057	.0308	19	.0034	.0005	.0049	19	.0548	.0050	.0730
W212	0	6	.0698	.0086	.2065	11	.0037	.0007	.0078	11	.0557	.0070	.0940
W213	0	14	.0200	.0062	.0340	19	.0034	.0009	.0051	18	.0543	.0110	.0720
W214	0	5	.0163	.0080	.0275	10	.0031	.0007	.0053	10	.0522	.0080	.0780
W215	0	8	.0265	.0071	.0654	8	.0036	.0025	.0051	8	.585	.0446	.0695

were made by shoreline sources (Vassos and Williams, 1981). Sources of contaminating coliforms included sewage treatment plants, storm drains and leaking septic tanks.

2.6 Five Finger Island

Prior to 1974, sewage from Nanaimo was discharged through two sub-marine outfalls located at Duke Point and Newcastle Island. In October 1974, a new outfall replaced the two smaller discharges. The outfall was located 2030 m offshore in 70 m of water (see Table 1 for outfall dimensions). Primary treatment with chlorination was not initiated until June, 1975 (Packman, 1977).

Permit No. 338 stipulated that 27,300 m^3/day was the maximum flow to be flushed through the "Y" shaped diffuser of the Five Finger Island outfall. Tidal flows affecting the dilution of sewage effluent were considerably weaker than those found in waters surrounding the southern tip of Vancouver Island (Thomson, 1981). Therefore, wind generated currents played a more important role in the distribution and mixing of effluent. According to Packman (1977) and Pomeroy and Packman (1981), the water column around Five Finger Island was typical of Georgia Strait. Stratification was more distinct in summer months than in winter. Seasonal temperature and salinity variation most likely represented changes in freshwater flows from the Nanaimo river, varied wind and tidal currents and surface warming due to insolation.

The monitoring programme conducted by Malaspina College covered pre- and post-operational as well as pre- and post-treatment surveys (Waters 1975a, b, c; Waters 1976a, b). Sampling sites from which surface samples and intertidal observations were made are seen in Figure 11. (The precise location of sampling sites used by Waters (1975, 1976) was not specified therefore, those seen in Figure 11 are not exact. Station 8 is 1.6 km offshore and not located in Figure 11.) Raw data obtained from the pre-operation, post-operation and post-treatment studies is summarized in Appendix III. Physical and chemical receiving water data fit a uniform

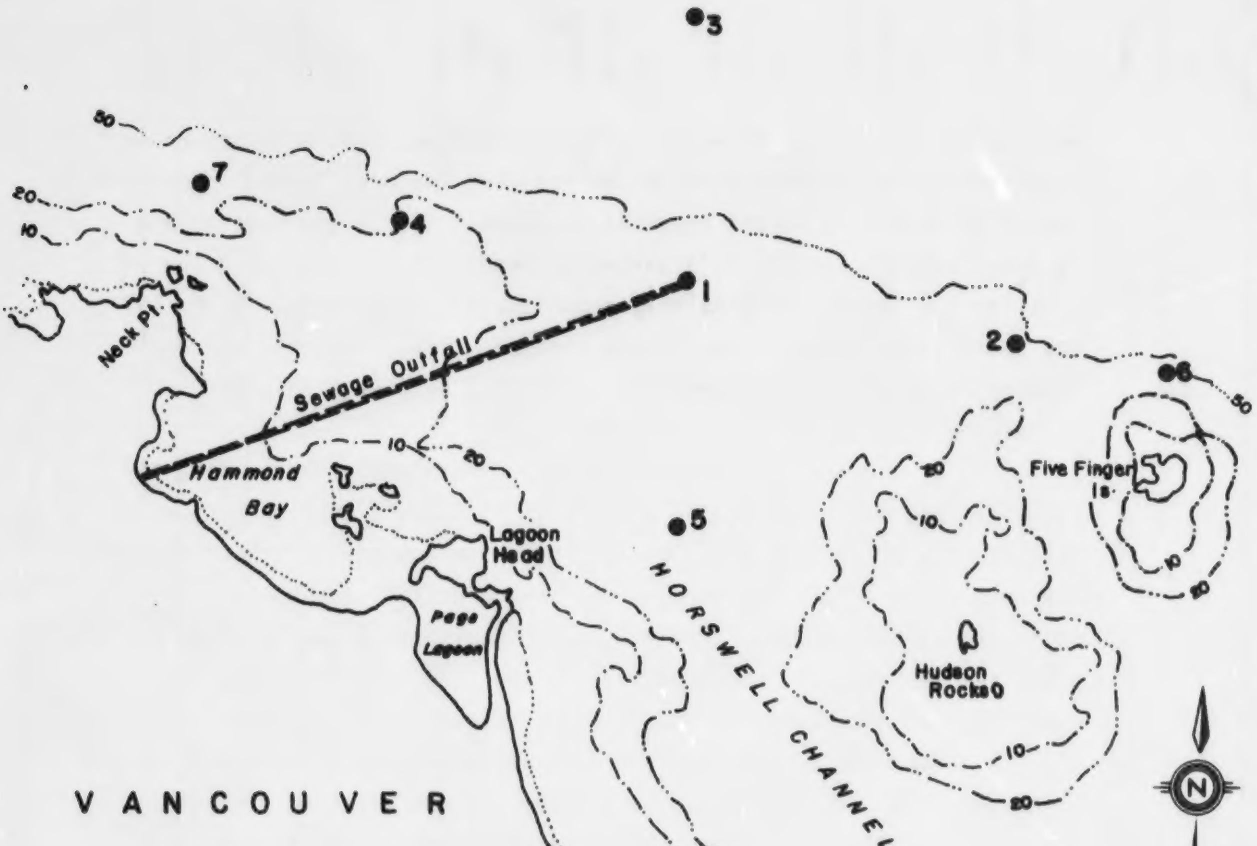

FIGURE 11 LOCATION OF SAMPLING STATIONS FOR MONITORING THE FIVE FINGER ISLAND MUNICIPAL OUTFALL (Reference: Adapted from Waters, 1976a)

seasonal distribution pattern indicating there was little variation in water quality attributable to sewage effluent (Waters, 1976b). Nutrient levels of receiving waters reported by Packman (1977) and Pomeroy and Packman (1981) (Appendix III) varied as result of introduced influences. That is, nitrite and particularly ammonia, increased over 1975 and 1977, pre-operational values (Pomeroy and Packman, 1981). Intertidal areas studied by Waters (1976b) remained unaffected by sewage related influences.

On average, the organic content of sediments surrounding the Five Finger Island outfall exceeded the Strait of Georgia average by a slight margin. The difference could be attributed to low size fraction sediment components and/or the presence of the sewage outfall but neither cause was confirmed by Pomeroy and Packman (1981). Sediments organic carbon contents presented in Table 14 increased in 1978 and 1980 reflecting the shift of sampling stations closer to the diffuser (Figure 12).

Appendix II indicates lead, zinc and copper in receiving waters increased from 1974 through to 1976. Mercury decreased only slightly.

As reported by Pomeroy and Packman (1981), trace metal concentrations in sediments changed very little from 1975 to 1978. However, between 1978 and 1980, when sampling was done closer to the diffuser, substantial increases in metals were recorded. Therefore the outfall was suspected of being the source of metals.

Shoreline coliform levels presented by Waters (1979b) were below the recreational contact standard. The same survey revealed the coliform contents of oyster tissue were slightly above the recommended concentration however, the source of the bacteria was undetermined. Primary chlorinated treatment reduced coliform counts to levels below the recreational contact standard (Pomeroy and Packman, 1981).

The area around Fiver Finger Island is used for recreational purposes as well as by commercial fishermen (Bell and Kallman, 1976).

TABLE 14 FIVE FINGER ISLAND: METAL AND ORGANIC CARBON CONCENTRATIONS IN SEDIMENT SAMPLES 1975-1980

SAMPLE TYPE	DATE	NO. OF SAMPLES		PARAMETER									DATA SOURCE
				Org. Carbon Content (%)	Co (ppm)	Cu (ppm)	Fe (%)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Hg (ppm)	
Surface	July-	9	Mean	-	12.09	30.53	2.28	393.46	31.20	10.63	66.29	-	Packman
Sediment	Aug.		Min.	-	5.0	11.5	1.5	122.1	11.8	0.0	10.9	-	1977
	1975		Max.	-	18.6	40.3	3.3	1240.2	43.1	18.7	97.5	-	
	Aug.	9	Mean	1.66	12.1	30.5	2.3	393.5	31.2	10.6	66.3	0.31	Pomeroy &
	1975		Min.	0.41	5.0	11.5	1.5	122.1	11.8	0.0	40.9	-	Packman
			Max.	2.7	18.6	40.3	3.3	1240.2	43.1	18.7	875.0	-	1981
	Aug.	9	Mean	1.53	12.0	26.1	1.9	216.2	25.8	5.4	54.2	0.1	Pomeroy &
	1975		Min.	0.9	5.4	11.7	1.0	100.4	12.3	0.0	27.6	0.0	Packman
			Max.	2.4	19.5	41.0	2.9	448.2	40.4	19.5	89.3	0.1	1981
	April	9	Mean	2.07	11.6	25.7	1.5	264.8	23.0	6.6	58.3	0.2	Pomeroy &
	1978		Min.	0.8	5.6	7.5	0.8	103.5	7.8	1.8	23.4	< 0.2	Packman
			Max.	2.8	19.1	35.6	2.3	403.2	34.4	10.3	89.9	0.3	1981
	Nov.	9	Mean	2.2	-	32.0	2.3	315.9	27.4	48.7	63.5	-	Pomeroy &
	1980		Min.	0.7	-	10.1	3.7	260.0	12.3	25.0	26.1	-	Packman
			Max.	4.3	-	53.5	1.5	1050.0	50.5	84.5	112.0	-	1981
	Nov.		Mean	2.68	6.5	11.4	1.43	242.5	8.0	3.0	30.4	-	Pomeroy
	1983		Min.	1.90	3.6	8.1	1.11	147.0	6.0	-	24.4	-	Unpublished
			Max.	4.74	8.8	18.7	1.78	673.0	10.0	-	36.2	-	
Sediment	April	11	Mean	-	8.4	31.0	2.0	316.6	28.2	4.4	61.8	0.9	Pomeroy &
Cores	1978		Min.	-	8.2	15.8	1.2	153.5	16.7	0.0	36.4	< 0.2	Packman
			Max.	-	20.3	51.2	2.5	540.8	40.2	10.9	89.2	0.4	1981

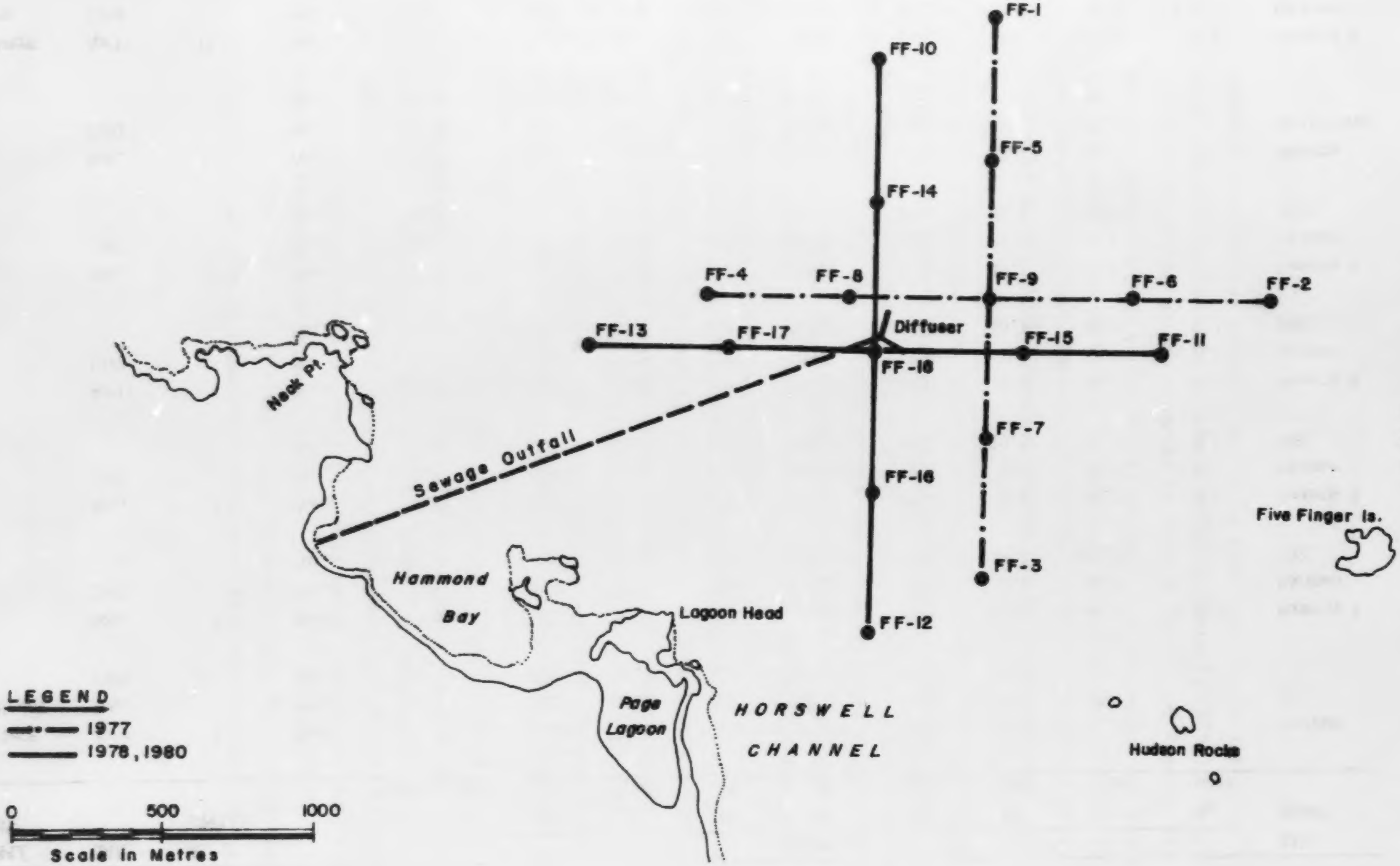

FIGURE 12 LOCATION OF SAMPLING STATIONS FOR MONITORING THE FIVE FINGER MUNICIPAL OUTFALL (Reference: Pomeroy and Packman, 1981)

Waters in the vicinity of the sewage outfall are used for salmon, shrimp and crab fishing (Bell and Kallmar, 1976). Although these organisms are not as sensitive to environmental changes as benthic communities, they are subject to influence originating from the sewage treatment plant.

Packman (1979) reports that the benthic community in the Five Finger outfall area was typical of a deep water community. Benthic grab samples indicated there was little environmental damage while species diversity and evenness of distribution were high. A later survey gives evidence that the benthic community surrounding the Five Fingers outfall had a different species composition than those surveyed away from the outfall (Pomeroy and Packman, 1981). None of the samples had characteristics of pollution affected communities (Pomeroy and Packman, 1981).

Seabed observations of the Five Finger outfall area were made in 1978 and 1980 during dives in the submersible vessel, Pisces IV. On both occasions the gravel and mud substrate was clearly visible so displayed little evidence of organic matter build-up. By 1980, non-biodegradable debris had accumulated around the diffuser (Pomeroy and Packman, 1981). The concentration of fish in the Five Finger Island diffuser area was the largest seen on any Pisces IV dive conducted by the Environmental Protection Service (M. Pomeroy, pers. comm.). It is apparent that, as Waters (1976b) noted, biological activity in the outfall area has been on the increase.

Analysis of prawn (Pandalus platyceros) and shrimp (P. borealis) tissue done in 1980 showed the commercially harvested crustaceans contained higher level of metals than in previous testing (Table 15) (Pomeroy and Packman, 1981). Copper, cadmium, iron, zinc and lead were found in concentrations substantially above 1977 levels (Pomeroy and Packman, 1981).

TABLE 15 FIVE FINGER ISLAND: TRACE METAL CONCENTRATIONS IN TISSUES (dry weight, ppm)

Reference: Pomeroy and Packman, 1981

ORGANISM	DATE	STATUS	Cu	Fe	Zn	Pb	Cd	Hg	Mg	Mn	Ag
Prawn *Pandalus platyceros*	Aug. 1977	No. of Values	1	1	1	1	1	1			
		Value	18.00	12.00	49.00	< 1.00	< 0.50	0.52			
	April 1978	No. of Values	3	3	3	3	3	3	3	3	3
		Mean	33.13	17.67	52.77	< 4.26	< 0.71	1.38	1813.3	4.01	50.27
		Min.	29.00	6.32	49.40	< 4.20	< 0.70	1.07	1760.0	2.21	25.90
		Max.	36.10	31.00	56.50	< 4.32	< 0.72	1.66	1860.0	5.56	67.00
	Nov. 1980	No. of Values	1	1	1	1	1	1			
		Value	123.00	231.00	65.20	< 3.86	1.01	0.10			
Shrimp *Pandalus borealis*	Aug. 1977	No. of Values	1	1	1	1	1	1			
		Value	27.00	21.00	54.00	< 1.00	< 0.50	0.26			
	Nov. 1980	No. of Values	1	1	1	1	1	1			
		Value	115.00	321.00	61.20	< 3.86	< 1.01	0.04			
Rockfish *Seabastes sp.*	Aug. 1977	No. of Values	3	3	3	3	3	3			
		Mean	7.07	120.00	30.00	4.33	< 0.50	0.47			
		Min.	5.60	41.00	22.00	< 1.00	< 0.50	< 0.07			
		Max.	8.50	230.00	42.00	11.00	< 0.50	0.74			
Squat Lobster *Munida quadrispina*	April 1978	No. of Values	1	1	1	1	1	1	1	1	1
		Value	32.70	30.10	51.30	< 3.66	1.51	0.78	3350.0	11.40	14.20

2.7 French Creek

The French Creek marine sewage outfall was constructed in the last few months of 1977. The accompanying sewage treatment plant (STP) was brought into service in February 1978 and was servicing residents of the Qualicum-Parksville area by August 1978 (L. Benoit, pers. comm.). The outfall extends 2438.4 m to a site where oceanographic conditions are characteristic of the Georgia Strait. Stratification resulting primarily from surface insolation was evident in August surveys but was almost non-existent in April (Pomeroy, 1982). Freshwater flows combined with wind and tidal currents effect the distribution of the French Creek sewage effluent.

Monitoring of the French Creek outfall receiving environment was conducted by the Environmental Protection Service at sampling stations presented in Figure 13. Pre-discharge monitoring was carried out in 1977 to provide comparative data for post-operation impact studies done in 1978 and 1980. Water quality data presented by Pomeroy (1982) (Table 16 and Appendix IV) demonstrated temporal variations which were attributed to normal seasonal fluctuations.

Sediment analysis gave evidence that sewage effluent is affecting the receiving environment (Pomeroy, 1982). Sampling stations in the eastern portion of the study area exhibited heavy metal concentrations which were above the pre-operational samples (Table 17). High background levels of organics and heavy metals were thought to reflect influences from French and Morningstar Creeks and prevailing currents. However, a continual rise in organic concentration of the French Creek area was evidenced by greater particle settlement and higher microbiotic activity. Sewage discharge was believed to be the major contributer of organics (Pomeroy, 1982). The organic and heavy metal content of sediment is a function of particle size (Pomeroy, 1982). Nearby creeks and fine particles from the effluent therefore contributed to the increase in heavy metal and organic content of the sediment.

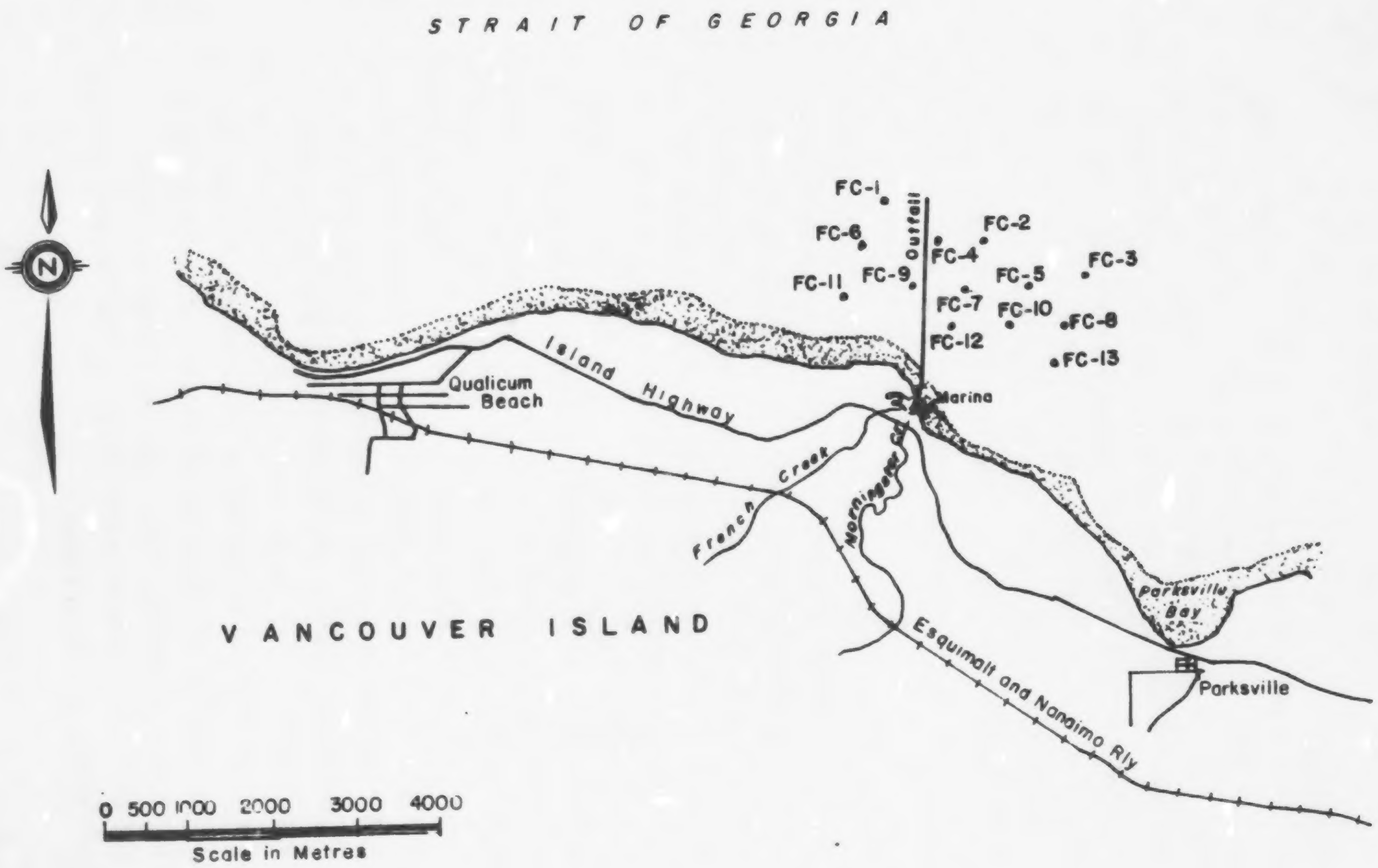

FIGURE 13 LOCATION OF SAMPLING STATIONS FOR MONITORING OF THE FRENCH CREEK MUNICIPAL OUTFALL (Reference: Pomeroy, 1982)

TABLE 16 FRENCH CREEK: WATER QUALITY MEAN NUTRIENT CONCENTRATIONS AT SURFACE AND 50 m DEPTH
Reference: Pomeroy, 1982

	TOTAL PHOSPHATE (mg/L)	ORTHO-PHOSPHATE (mg/L)	NITRATE (mg/L)	NITRITE (mg/L)	AMMONIA (mg/L)
August 24, 1977					
0 m	NS*	0.046	0.176	0.006	0.013
50 m	NS	0.072	0.376	0.006	0.010
April 27, 1978					
0 m	0.071	NS	0.238	< 0.005	0.008
50 m	0.081	NS	0.362	< 0.005	< 0.005
November 12, 1980					
0 m	0.054	0.062	0.271	< 0.005	0.024
50 m	0.059	0.069	0.298	< 0.005	0.019

NS* = samples not obtained

TABLE 17 FRENCH CREEK: MEAN HEAVY METAL CONCENTRATIONS IN SURFACE SEDIMENTS

Reference: Pomeroy, 1982

DATE	MEAN HEAVY METAL CONCENTRATION								
	Cd (ppm)	Co (ppm)	Cu (ppm)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Fe (ppm)	Hg (ppm)
August 24 1977	NA	5.171	9.102	99.619	8.413	NA	24.707	9665	0.032
April 27 1978	NA	4.524	8.685	95.298	7.192	NA	23.572	7392	0.023
November 12 1980	L0.56	NS	10.269	197.615	10.569	23.86	23.238	14823	NS

NA = not analysed

NS = not sampled

Grab sampling data showed polychaete worms to be the most abundant of infauna. Diverse invertebrate communities were indicated by the lack of dominant species. Species diversity was greatest east of the outfall and ranged from 25 to 37.

A comparison of tissue metal levels in English Sole (Parophrys vetulus) between 1977 and 1980 was made by Pomeroy (1982) (Table 18). Copper and mercury decreased by one half while zinc and iron increased by a factor of two. There were a large number of rockfish observed around the outfall pipe during the 1980 Pisces IV submersible dive with an increase in the local population noted during the 1983 dive (M. Pomeroy, pers. comm.).

In October 1983, Pomeroy (pers. comm.) observed from the Pisces IV that undercutting was more severe than noted in previous dives. Some segments of the French Creek outfall pipe were completely suspended. Despite this local disturbance, the general outfall area was free of visible effects from sewage disposal (Pomeroy, pers. comm.).

2.8 Campbell River

The 16,411 residents of Campbell River are served by two sewage outfalls; one constructed in 1964 which discharges at a depth of 11 m and the other in 1974 which discharges at 6.9 m. Both outfalls are now serviced by the same secondary sewage treatment plant. Outfall details are presented in Table 1. Permit no. 109 requires monitoring of effluent for B.O.D. and S.S. however monitoring of receiving waters is not a criteria of the permit.

The STP rarely operates at full capacity. During periods of wet weather, storm overflows are utilized.

A sanitary survey of the Municipality of the District of Campbell River identified the Campbell River Water Pollution Control Centre (WPCC) as a contributor of bacterial pollution to Discovery Passage (Higgs, 1967a). However, a Shellfish Growing Water Sanitary Survey did not mention the Campbell River WPCC as one of the major contributors of

TABLE 18 FRENCH CREEK: MEAN HEAVY METAL CONCENTRATIONS IN ENGLISH SOLE (Parophyrs vetulus). Levels Expressed in Wet and Dry Weight

Reference: Pomeroy, 1982

TRAWL	Cu		Fe		Zn		Hg	
	dry	wet	dry	wet	dry	wet	dry	wet
	(ppm)		(ppm)		(ppm)		(ppm)	
1977								
FCT-1	11.3	2.4	16.4	3.4	33.8	7.1	0.19	0.04
FCT-2	11.5	2.5	13.3	2.9	25.3	5.5	0.18	0.04
FCT-3	11.7	2.6	15.3	3.3	24.7	5.3	0.27	0.06
FCT-4	13.2	2.9	12.4	3.4	26.0	5.5	0.13	0.03
FCT-5	10.3	2.4	22.7	5.2	42.5	9.9	0.13	0.03
1980								
FCT-3	6.0	1.3	39.5	8.2	65.3	13.9	0.12	0.02

fecal coliform (Arney and Kay, 1976). Recommended shellfish closures were based on high coliform levels originating from sources other than the WPCC (Arney and Kay, 1976).

The prospect of light industry development in the Campbell River area led to construction of an STP fourteen miles north of the city during 1983. The expected developments failed to materialize thus leaving the STP dormant (P. Skognes, District of Campbell River, pers. comm.). When the STP will be brought into operation is not known.

2.9 Powell River

Powell River has three sewage outfalls serving a population of 13,305. As seen in Table 1, secondary treatment was employed at the Westview and Town Site treatment plants while the effluent expelled from the Wildwood outfall undergoes chlorination. The short Wildwood outfall will be replaced by a deep sea outfall in 1984 (L. King, pers. comm.).

A bacteriological survey conducted by EPS during November and December, 1975 quantified the bacterial levels of marine waters overlying shellfish beds (Kay, 1976). A concurrent investigation (Higgs, 1976b) concluded the major sources of bacterial pollution were the storm tank overflow from the Powell River Water Pollution Control Plant (WPCP) and the sewage bypass from the Westview WPCP. In addition to these sources of bacteria, the Wildwood Heights Sewage Lagoon was suspected of being a major contributor of bacterial contamination (Kay, 1976). The intertidal waters of Powell River were contaminated by fecal pollution to the extent that consumption of molluscan shellfish was potentially hazardous (Kay, 1976).

2.10 Prince Rupert

Domestic waste generated by the 16,786 residents of Prince Rupert is discharged via three sewage outfalls and six storm overflows all of which terminate in the Prince Rupert Harbour (Figure 14). The dimensions of the outfalls are presented in Table 1.

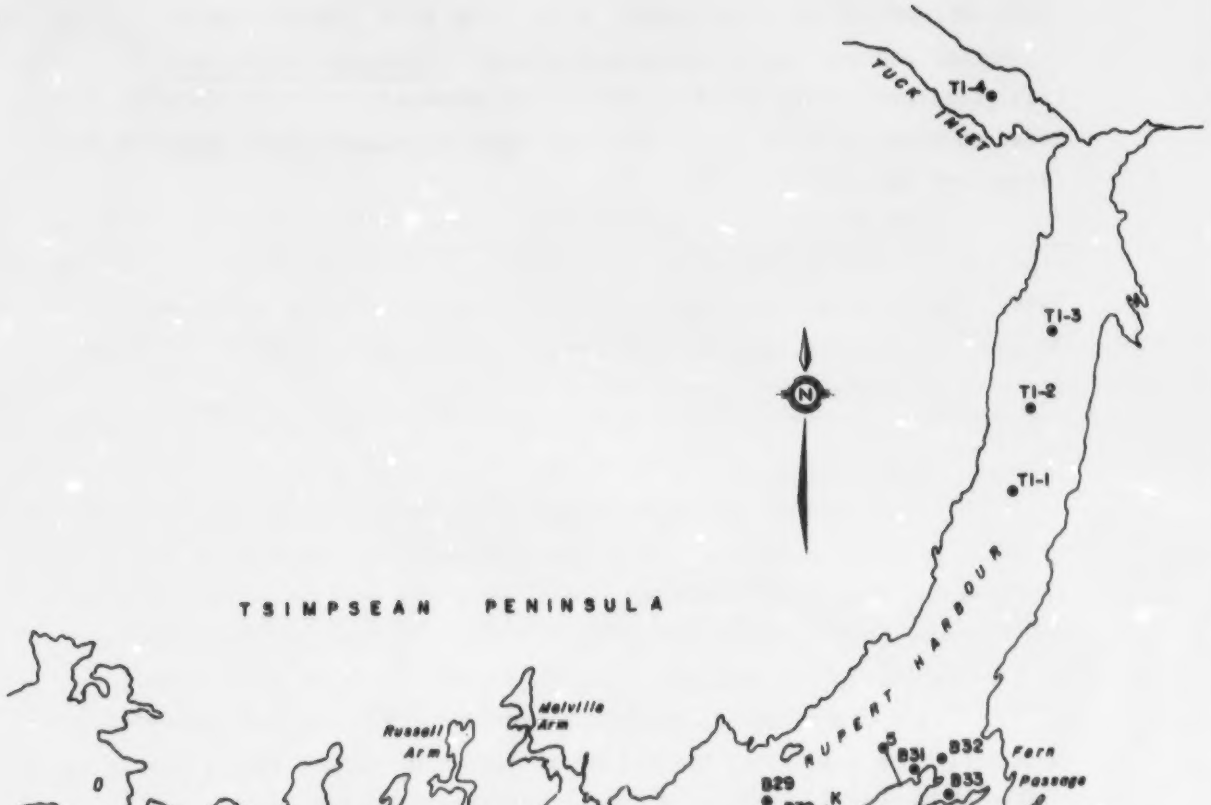

FIGURE 14 LOCATION OF SAMPLING STATIONS FOR MONITORING OF THE PRINCE RUPERT MUNICIPAL OUTFALLS

Tidal ranges over 7 m are encountered in the Prince Rupert area (Thomson, 1981) which have a strong influence on disperion of effluent in the Prince Rupert Harbour. Vigorous southeasterly winds blow from November through to February having a mixing effect in the Hecate Strait and surrounding areas (Thomson, 1981). In summer months, freshwater runoff replaces the southeasterlies as the primary dispersal agent (Thomson 1981).

A marine study by Associated Engineering (1977) reported that physical properties of the Prince Rupert Harbour water should have caused the main body of the effluent plumes to remain submerged below the surface. The report (Associated Engineering, 1977) noted stratification of receiving waters at all times of the year. Billions of cubic metres of tidal water move in and out of the harbour during each tidal cycle which resulted in a high degree of mixing and assimilation of sewage effluent (Associated Engineering, 1977).

Permit No. 5577 stipulates that water samples collected at seven sampling stations (Figure 14) should be obtained every three months. The parameters measured were total and fecal coliforms, Secchi disc, turbidity and floatables. Permit No. 5577 required that testing of shellfish for coliforms be done biannually.

The Environmental Protection Service carried out sampling of sediments in the Prince Rupert Harbour in 1979, 1980 and 1981 (EPS, unpublished data) from sites presented in Figure 14. The results have been presented in Tables 19 and 20. Copper, cadmium, lead and zinc concentrations noted for sampling station C were elevated far above concentrations recorded at all other stations. These values influenced the mean heavy metal concentrations such that the 1980 and 1981 levels increased over 1979 concentrations. Figure 14 presents sampling sites noted in Table 19.

TABLE 19 PRINCE RUPERT: HEAVY METAL CONCENTRATIONS IN SUBTIDAL SURFACE SEDIMENTS, June 6-9, 1979
Reference: EPS, unpublished data

SAMPLING STATION	DEPTH (m)	Cd (ppm)	Cu (ppm)	Fe (%)	Hg (ppm)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Cr (ppm)
B-19	52	< 1.21	51.10	3.72	0.312	1005.00	28.85	14.03	105.50	83.90
B-20	48	< 1.21	68.50	3.85	0.356	1060.00	27.90	9.69	118.00	34.80
B-21	22	< 1.22	60.10	3.27	0.578	695.00	22.70	12.35	108.50	33.10
B-21a	4	< 1.22	251.00	2.51	1.690	335.50	16.85	58.20	162.00	32.60
B-22	22	< 1.22	150.00	3.44	0.378	485.50	23.40	312.00	192.50	35.00
B-23	18	< 1.24	37.70	3.44	0.883	522.00	24.30	9.73	97.50	36.20
B-24	24	1.81	444.50	2.84	0.538	441.00	24.60	69.40	405.50	25.60
B-25	69	< 1.22	84.30	3.95	0.393	618.00	31.25	9.73	97.50	36.20
B-26	27	2.67	202.50	3.58	1.270	586.00	23.75	154.00	845.00	28.60
B-27	48	< 1.17	60.80	4.14	1.270	621.50	32.05	9.39	120.50	39.30
B-28	14	7.30	897.50	4.16	2.660	423.50	26.25	181.00	1515.00	45.10
B-29	55	< 1.20	126.00	4.26	0.378	636.00	31.40	14.50	162.00	40.50
B-30	50	< 1.23	212.00	3.86	1.360	524.50	31.95	51.85	267.00	39.90
B-31	3	< 1.17	334.00	4.70	2.870	294.00	28.60	365.50	576.50	49.30
B-32	9	1.61	314.00	3.46	0.305	396.00	26.40	177.00	422.00	50.90
B-33	15	< 1.23	99.20	2.79	0.513	386.50	21.80	40.55	166.00	32.90
B-34	8	< 1.19	54.50	1.89	0.425	316.00	12.15	32.50	95.70	26.00
TI-1	66	< 1.23	59.50	4.19	1.420	557.00	35.40	15.65	130.50	41.80
TI-2	58	< 1.23	55.40	4.31	0.980	567.00	34.05	16.30	130.50	39.90
TI-3	54	< 1.22	53.10	4.17	0.760	537.00	33.50	15.40	124.00	38.70
TI-4	62	< 1.18	34.70	3.28	1.110	394.00	23.35	9.41	96.40	33.80
Mean Value for all Stations (n=21)		1.62	173.82	3.61	2.200	542.90	26.69	75.15	283.91	36.88

TABLE 20 PRINCE RUPERT: HEAVY METAL CONCENTRATIONS IN SUBTIDAL SURFACE SEDIMENTS
August 21, 22, 1980 and October 13, 1981

Reference: EPS, unpublished data

SAMPLING STATION	Cd (ppm)		Cu (ppm)		Fe (%)		Mn (ppm)		Ni (ppm)		Pb (ppm)		Zn (ppm)		Hg (ppm)	
	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981	Aug. 1980	Oct. 1981
A	< 1.23	1.10	276.00	276.00	2.69	1.81	410.00	242.00	10.50	11.00	54.50	18.00	199.00	166.00	< 0.098	0.25
B	< 1.49		92.00		4.30		615.00		37.50		72.50		144.00		< 0.092	
C	26.80	29.00	2850.00	2300.00	4.00	11.90	422.00	336.00	26.20	27.00	336.00	374.00	4360.00	4590.00	-	0.34
F		3.60		1450.00		3.73		526.00		21.00		59.00		647.00		0.40
G	< 1.36	3.20	535.00	998.00	3.85	3.69	505.00	509.00	29.70	21.00	97.50	55.00	354.00	578.00	< 0.096	0.57
H	5.50	1.70	715.00	448.00	4.36	3.36	536.00	447.00	38.90	17.00	147.00	61.00	765.00	336.00	< 0.096	0.56
I	< 1.21	1.80	160.00	229.00	4.11	4.01	535.00	490.00	34.00	23.00	127.00	46.00	299.00	310.00	< 0.098	0.64
J	< 1.25	0.80	171.00	144.00	3.88	3.78	482.00	524.00	33.60	21.00	80.40	31.00	210.00	179.00	-	0.44
K	< 1.24		205.00		3.77		492.00		33.20		85.50		228.00		-	
L	< 1.21		227.00		4.21		550.00		34.00		82.00		228.00		< 0.097	
M		0.60		112.00		3.83		565.00		20.00		26.00		159.00		0.23
N		0.60		68.20		4.14		736.00		20.00		27.00		142.00		0.31
O		0.40		144.00		4.20		829.00		21.00		91.00		141.00		0.40
P		0.60		68.30		4.09		646.00		23.00		21.00		128.00		0.32
Mean Value for all Stations	4.59	3.95	692.33	648.86	3.91	4.41	505.11	531.82	30.84	20.45	120.28	73.55	754.11	670.44	0.096	0.41

2.11 Lions Gate

The Lions Gate sewage treatment plant services a large portion of the residents of North and West Vancouver and discharges sewage effluent into the First Narrows. Dimensions of the outfall pipe have been presented in Table 1.

Winds and tidal currents combine with pressures of waters squeezing through the shallow (15 m) First Narrows to create turbulence in the immediate area of the Lion's Gate Bridge (Thomson, 1981). Current velocities in the Narrows range from 1.0 km/hr to 4.6 km/hr (B.C. Research, 1981). The major source of fresh water is the Capilano River whose peak flows are in autumn and winter. The Fraser River exerts its influence in the spring when a brackish layer of water interupts the seaward flow of fresh water from local rivers (Thomson, 1981). Winds predominantly blow in an east-west direction.

Permit No. 30 required sampling of the Lion's Gate sewage effluent but did not include monitoring of receiving waters as a criteria of PE-30. Chlorination of the effluent is carried out from May to September. Digested sludge is released regularly on the ebb tide.

Sampling of waters in the First Narrows (Figure 15) revealed levels of ammonia ranged from the low value of 0.042 ppm to 0.1360 ppm over the diffuser manifold at slack tide (B.C. Research, 1981). EQUIS data, summarized in Appendix III, presents ammonia levels ranging from < 0.0100 to 0.0900 ppm.

Mathematical model predictions suggest sustantial deposition of sewage sludge solids may have collected in the vicinity of the outfall (EPS Memorandum, 1983).

The B.C. Research Report (1981) concluded salmon were not affected by sewage efluent but this was based on the assumption that salmon inhabit the estuary for a short period each year. According to the Habitat Management Division of Fisheries and Oceans (EPS Memorandum, 1983), chinook juveniles utilize the Capilano river estuary throughout the year. Therefore, the possibility of sewage related influences affecting juvenile and adult salmon cannot be ignored.

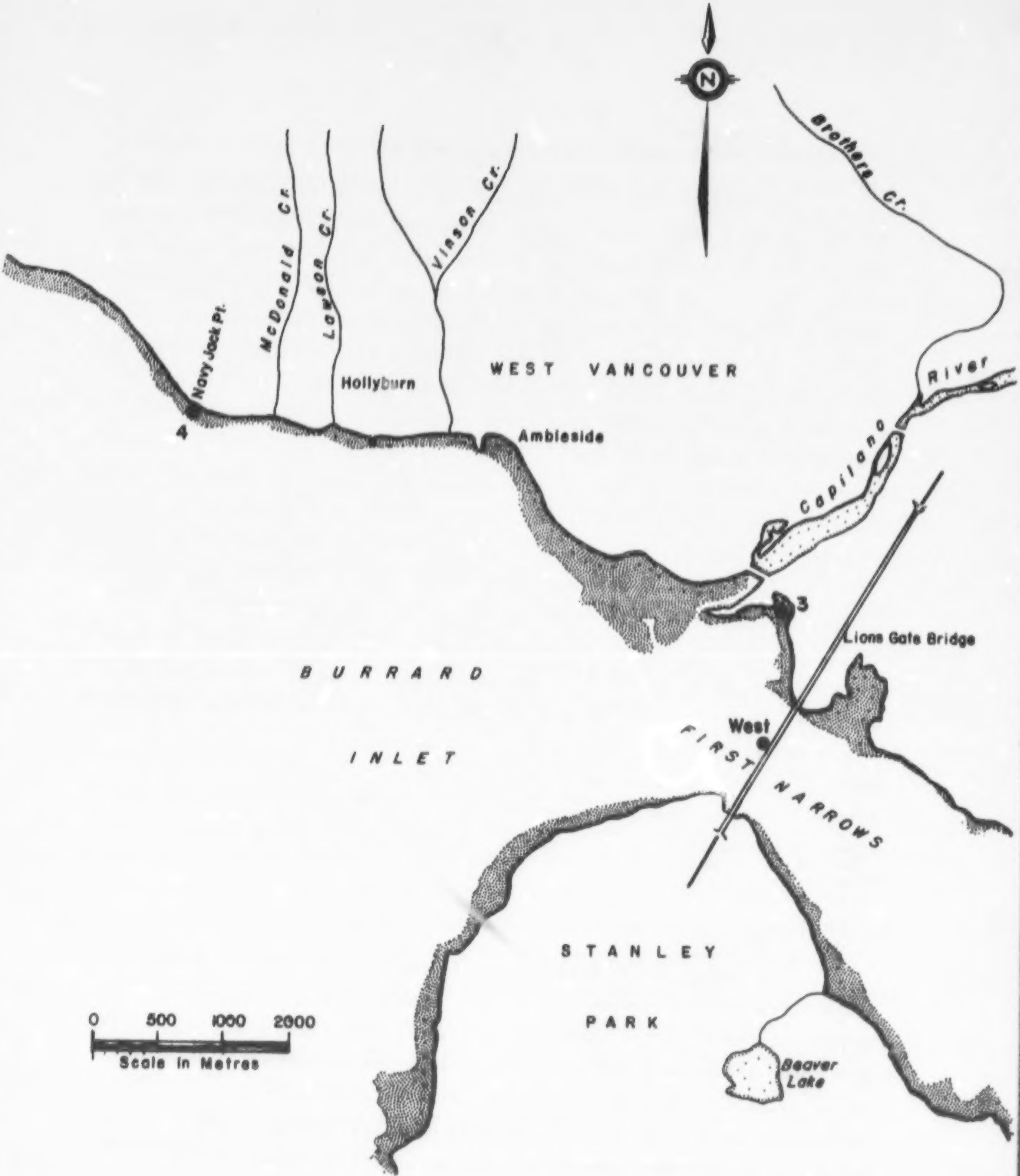

FIGURE 15 LOCATION OF SAMPLING STATIONS FOR MONITORING OF THE LIONS GATE MUNICIPAL OUTFALL (Reference: Sampling Station Descriptions from Greater Vancouver Regional District)

3.0 DISCUSSION

Seventy percent of the population of Brtish Columbia inhabits the coastal region bordering the Straits of Georgia and Juan de Fuca (Thomson, 1981). The water uses are varied and are often in conflict with each other. That is, they serve as a receptacle for industrial and domestic wastes while providing a waterway for spawning salmon and commercial traffic. Marine environments between Vancouver Island and the mainland are not subject to harsh climatic treatment of an open coast line but may be considered a semi-protected area whose deep waters are replaced approximately once a year (Waldichuk, 1983). A variety of commercially valuable crustaceans and pelagic fish utilize the Straits to support them during one or all stages of their life cycles. It is therefore in the best interest of British Columbians to protect these marine waters from pollution.

Pollution, as defined by the GSAMP (United Nations Group of Experts on Special Aspects of Marine Pollution) is the "introduction of substances into the marine environment that result in harm to living re sources" (Bascom et al, 1978). The waters considered in this report have been free of major pollution problems however, local degradation resulting from disposal of industrial and municipal waste is evident (Waldichuk, 1983). In the discussion which follows, attention has been given to changes in the marine environment as well as to the sublethal aspect of "harm" incurred to "living resources" as a result of marine sewage disposal.

3.1 Nutrients

Disposal of untreated sewage to the sea has been attractive to authorities as it minimizes the need for sewage treatment thereby minimizing the financial burden on taxpayers. Municipal waste has, in the past, been effectively assimilated by the marine environment. However, recent attention has been directed to problems associated with eutrophication and its relationship with municipal wastes. More specifically, nitrogen loading has been a concern to scientists as nitrogen is known to be the limiting nutrient in marine environments (Ryther and Dunstar, 1971). Nutrient enrichment may stimulate growth of phytoplankton (Barlott _et al_, 1983). An increase in primary productivity is largely dependent upon the nitrate concentration of the marine environment (Parsons, 1984).

An increase in primary productivity can have repercussions throughout the food chain. Figure 16 presents trophic interactions which are vulnerable to quantitative changes of phytoplankton populations. The illustration (Figure 16) indicates the major links through which the results of nutrient loading are transmitted from primary to tertiary producers.

The detection and measurement of eutrophication through biological indicators such as phytoplankton productivity, species composition and diversity have been reported extensively (Karydis _et al_, 1983). These indices are highly sensitive since they reflect interactions of organisms with each other and with the physical and chemical environment (Karydis _et al_, 1983). They require elaborate data collection and processing and analysis by a variety of specialists.

Receiving water data collection carried out for the municipal marine outfalls considered in this review has been sporadic and the recording accuracy of some information is questionable. Therefore, the intricate manipulations of nutrient data involved in measuring eutrophication through biological indicators is not suited to receiving environments of the sewage outfalls being reviewed. Data presented here indicates there is no nutrient enrichment in marine waters adjacent to the outfalls (Vassos, 1982a; Hoff, 1981). Any fluctuations in nutrient parameters fit a uniform seasonal distribution pattern indicating there has been little variation in water quality attributable to sewage effluent (Vassos, 1982a; Hoff, 1981; Waters, 1976b; Pomeroy, 1982; Goyette _et al_, unpublished). The sewage outfalls located in the study area terminate in well flushed waters which appear to alleviate possibilities of nutrient enrichment.

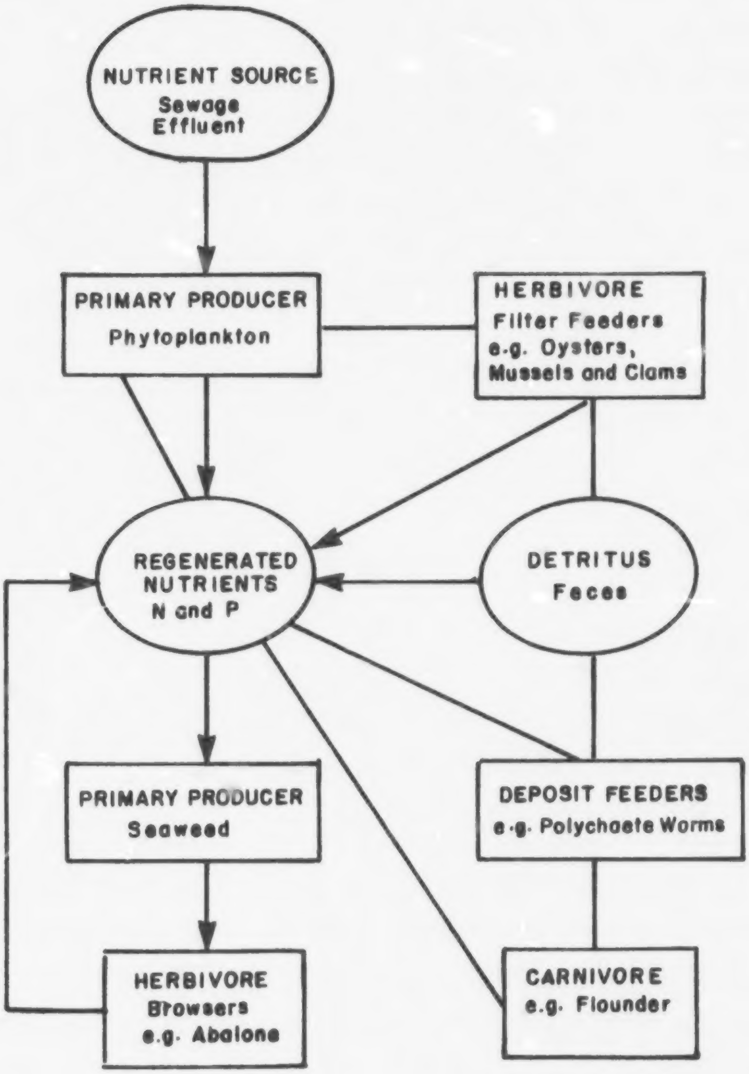

FIGURE 16 SCHEMATIC REPRESENTATION OF TROPHIC INTERACTIONS ILLUSTRATING THE LINK BETWEEN NUTRIENT LOADING AND COMMERCIALLY HARVESTABLE MOLLUSCS (Reference: Chapman, P. M., et al, 1979)

Because all evidence suggests there is little nutrient enrichment in sewage outfall areas reviewed herein, a worst case situation is one of low level eutrophication. Using controlled experimental ecosystems, Parsons (1984) demonstrated that induced low level nutrient enrichment did not result in changed diversity of phytoplankton and protozoan communities. It has been reported (Parsons, 1984) that inorganic and organic nutrient enrichment may elicit a number of different biological strategies as seen in Figure 17. It was noted that only in extreme cases would nutrient enrichment lead to an increase in pelagic tertiary production or an increase in benthic secondary production.

Sensitive methods of detection and measurement of eutrophication are available (illustrated by the eutrophication index utilized by Karydis _et al_, 1983). However, the water quality of marine environments surrounding municipal outfalls covered in this review suggests such detailed analysis is not yet warranted. This is supported by experiments which indicate more than low level eutrophication is necessary to cause an upset in trophic level production (Parsons, 1984).

The toxicity of ammonia to aquatic life has been a topic of recent concern. The chemical state of ammonia determines its toxicity. Un-ionized ammonia (NH_3) has been shown to be the toxic component of solutions (Stober _et al_, 1977). Concentrations of NH_3 increase with increasing pH and temperature and decreasing salinity (Stober, _et al_, 1977). Ammonia production is associated with the amount of substrate and attachable surface and is to some extent governed by bacterial activity (Parsons, 1984). Zooplankton also contribute to the ammonia pool (Corkett and McLaren, 1978). While ammonia is introduced to the marine environment in the form of domestic waste, the sources mentioned above influence measurements of ammonia in receiving waters. Variations in physical characteristics of study areas reduce the comparability of ammonia levels between testing locations.

Water quality records utilized in this review, represent quantities of dissolved ammonia (NH_4^+) as opposed to the

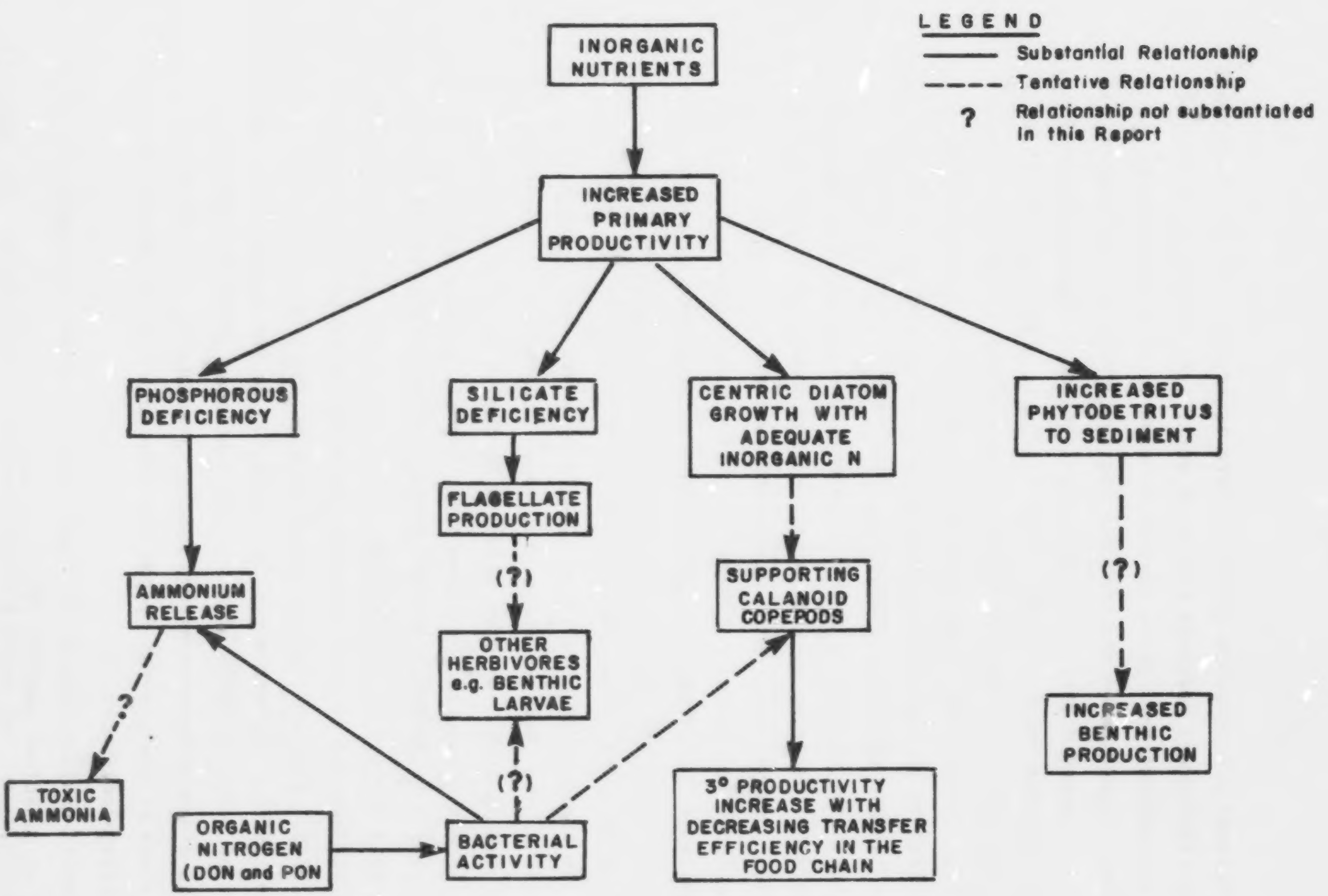
LEGEND
Substantial Relationship
Tentative Relationship
? Relationship not substantiated in this Report
INORGANIC NUTRIENTS
INCREASED PRIMARY PRODUCTIVITY
PHOSPHOROUS DEFICIENCY
SILICATE DEFICIENCY
CENTRIC DIATOM GROWTH WITH ADEQUATE INORGANIC N
INCREASED PHYTODETRITUS TO SEDIMENT
FLAGELLATE PRODUCTION
(?)
SUPPORTING CALANOID COPEPODS
(?)
AMMONIUM RELEASE
OTHER HERBIVORES e.g. BENTHIC LARVAE
INCREASED BENTHIC PRODUCTION
?
(?)
TOXIC AMMONIA
ORGANIC NITROGEN (DON and PON
BACTERIAL ACTIVITY
3° PRODUCTIVITY INCREASE WITH DECREASING TRANSFER EFFICIENCY IN THE FOOD CHAIN

FIGURE 17 SUMMARY OF SOME CONTROLLED ECOSYSTEM EXPERIMENTS ON NUTRIENT ENRICHMENT IN MARINE ECOSYSTEMS (Reference: Parsons, 1984)

un-ionized form of ammonia (NH_3) mentioned in literature sources (Stober et al, 1977; Clark, 1978). Therefore, there is little basis of comparison between the data presented here and that reported elsewhere. Macaulay Point ammonia levels of 0.148 and 0.084 ppm (Appendix I) were noted as being extreme (Hoff, 1981). It should be remembered that a source of ammonia other than sewage effluent was suspected as causing elevated ammonia levels off Macaulay Point (Hoff, 1981). The high ammonia concentrations for sampling stations W1 and S3 were noted by Hoff (1981), Vassos (1982a) and EQUIS (See Appendix I). Data reported by the WMB does not correspond with that of the other data sources.

Data on the effect of ammonia on marine organisms is limited and in the past information has been reported in conjunction with studies on freshwater species (U.S. EPA, 1976). Levels of un-ionized ammonia in the range of 0.2 to 2.0 ppm have been shown to be toxic to some species of freshwater aquatic life (U.S. EPA, 1976). Literature cited by the U.S. Environmental Protection Agency (U.S. EPA, 1976) indicates that at total ammonia ($NH_3 + NH_4^+$) concentrations of 3 ppm trout become hyperexcitable. However, even in dilute saline waters, the ratio $NH^+{}_4/NH_3$ increases thereby reducing the concentration of toxic NH_3 (U.S. EPA, 1976). The difficulty in estimating the toxicity of the reported high levels of ammonia is apparent.

Parsons (1984) noted that in experiments where both ammonium and nitrate uptake were studied, the uptake of ammonium by diatom dominated phytoplankton is generally more rapid than for nitrate. This suggested the dominance of ammonium in domesic sewage would be beneficial to the pelagic food chain of large diatoms and calanoid copepods (Parsons, 1984). Therefore, the introduction of small quantities of ammonium to the marine environment should not present a toxicity hazard.

3.2 Metals

Metals entering the marine environment may act as toxic pollutants which disrupt marine food chains and may pose a threat as contaminants of human food. The fate of metals in aquatic systems is influenced by changes in pH, temperature, salinity, by the process of sedimentation and by microbial activity (Chapman, 1979). Water, sediment, and biota are the metal reservoirs although sediments are the major repository which may contain over 99% of the metals in an aquatic environment (Renfro, 1973). It is difficult to determine amounts of metals in a particular aquatic environment when comparisons between locations are made because background levels vary considerably. Distinguishing between natural levels and those which originate from anthropogenic sources is another problem to be considered. In light of these observations, relative metal levels of the receiving environments involved in this report will be noted. This data is presented graphically in Figures 18-22, for mercury, copper, lead, zinc and cadmium respectively.

Comparing levels of mercury in sediment samples collected in the vicinity of the selected sewage outfalls, it is evident that mercury levels in the marine environment surrounding the concerned outfalls were elevated in two cases. French Creek sediment had a low mercury concentration of 0.032 ppm (Table 18) which is below the Five Finger Island mean sediment mercury concentration of 0.23 ppm (derived from Table 14). However, McMicking Point and Prince Rupert had higher mean sediment mercury concentrations of 0.73 ppm and 0.90 ppm respectively. Similar measurements in Puget Sound ranged from 0.01 to 1.00 ppm (reported by Chapman, 1979).

Both inorganic and organic forms of mercury can be converted to the toxic, methylated form by microorganisms in sediment (Garrett _et al_, 1980). However, the occurrence of methylation is dependent upon the sediment mercury concentration, pH, oxygen, hydrogen sulfide availability (Garrett _et al_, 1980) and therefore varies according to natural conditions. Methylated mercury may be biomagnified through the food chain resulting in organisms of higher trophic levels accumulating mercury to concentrations greater than that of ambient water.

In his study of Los Angeles outfalls, Bascom (1983) concluded the presence of methylated mercury was natural and not the result of man's ordinary wastes. Mercury in sediments around Los Angeles County rarely

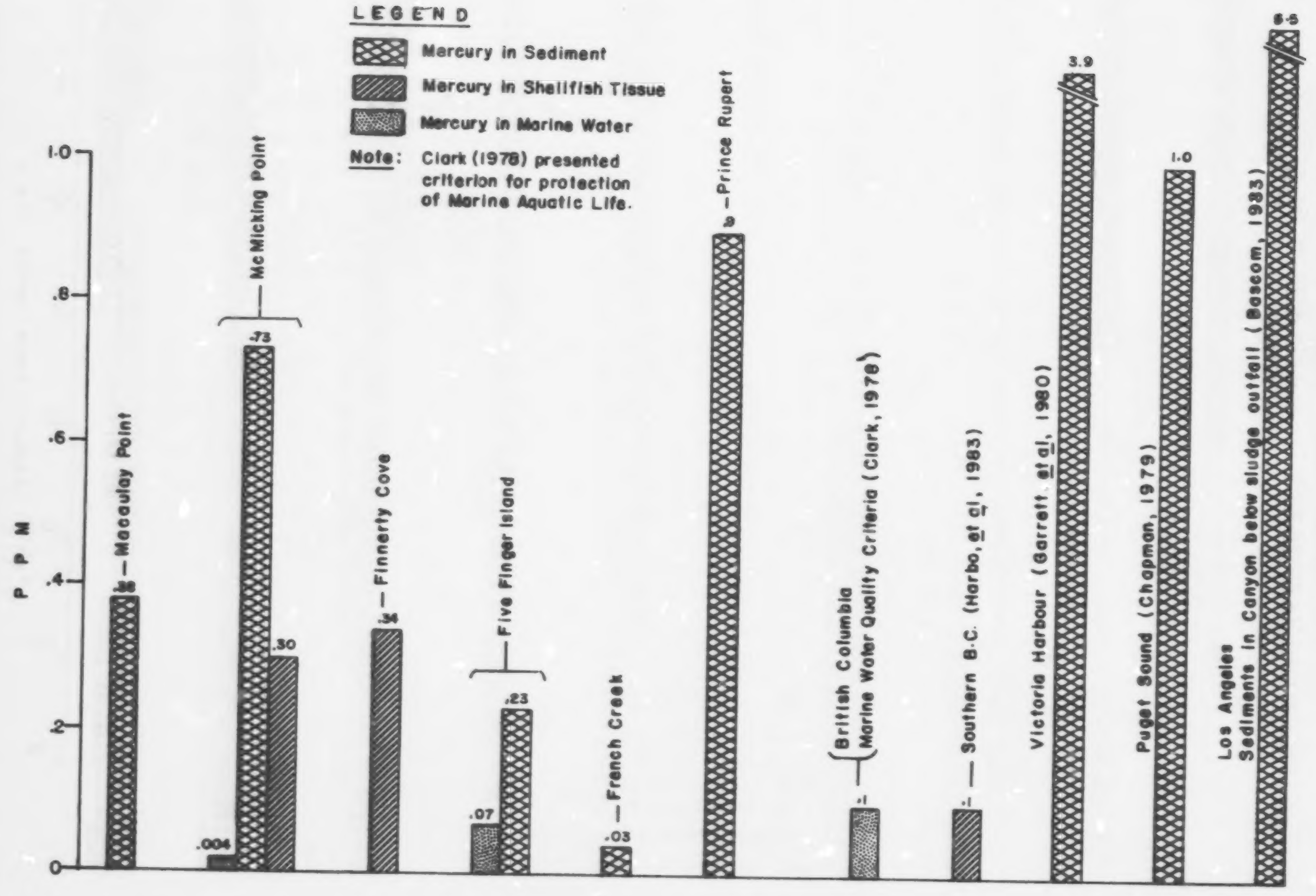

FIGURE 18 COMPARISON OF MEAN MERCURY CONCENTRATIONS IN MARINE WATER, SURFACE SEDIMENT AND SHELLFISH TISSUE FOR SELECTED OUTFALL AREAS

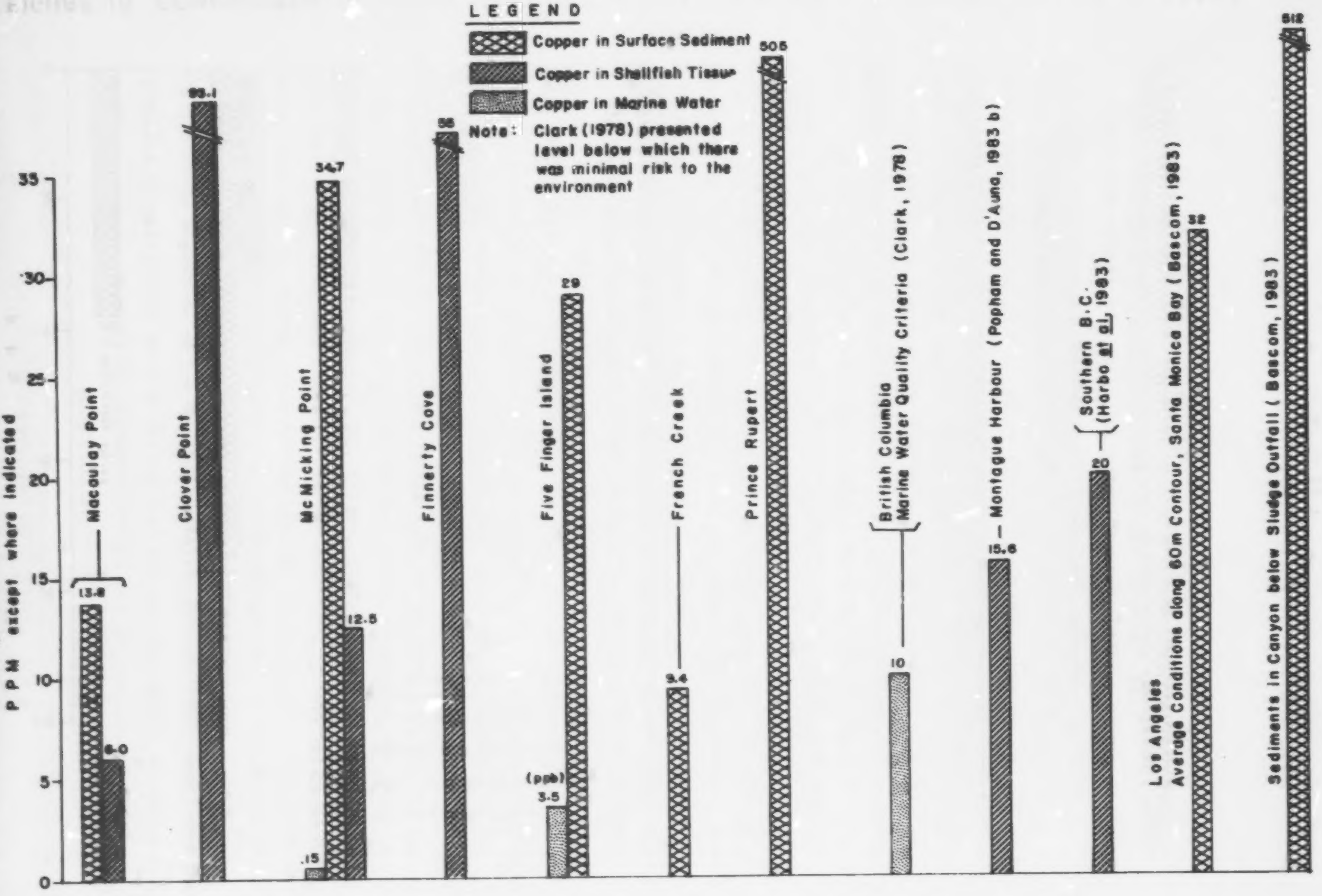

FIGURE 19 COMPARISON OF MEAN COPPER CONCENTRATIONS IN MARINE WATER, SURFACE SEDIMENT AND SHELLFISH TISSUE FOR SELECTED OUTFALL AREAS

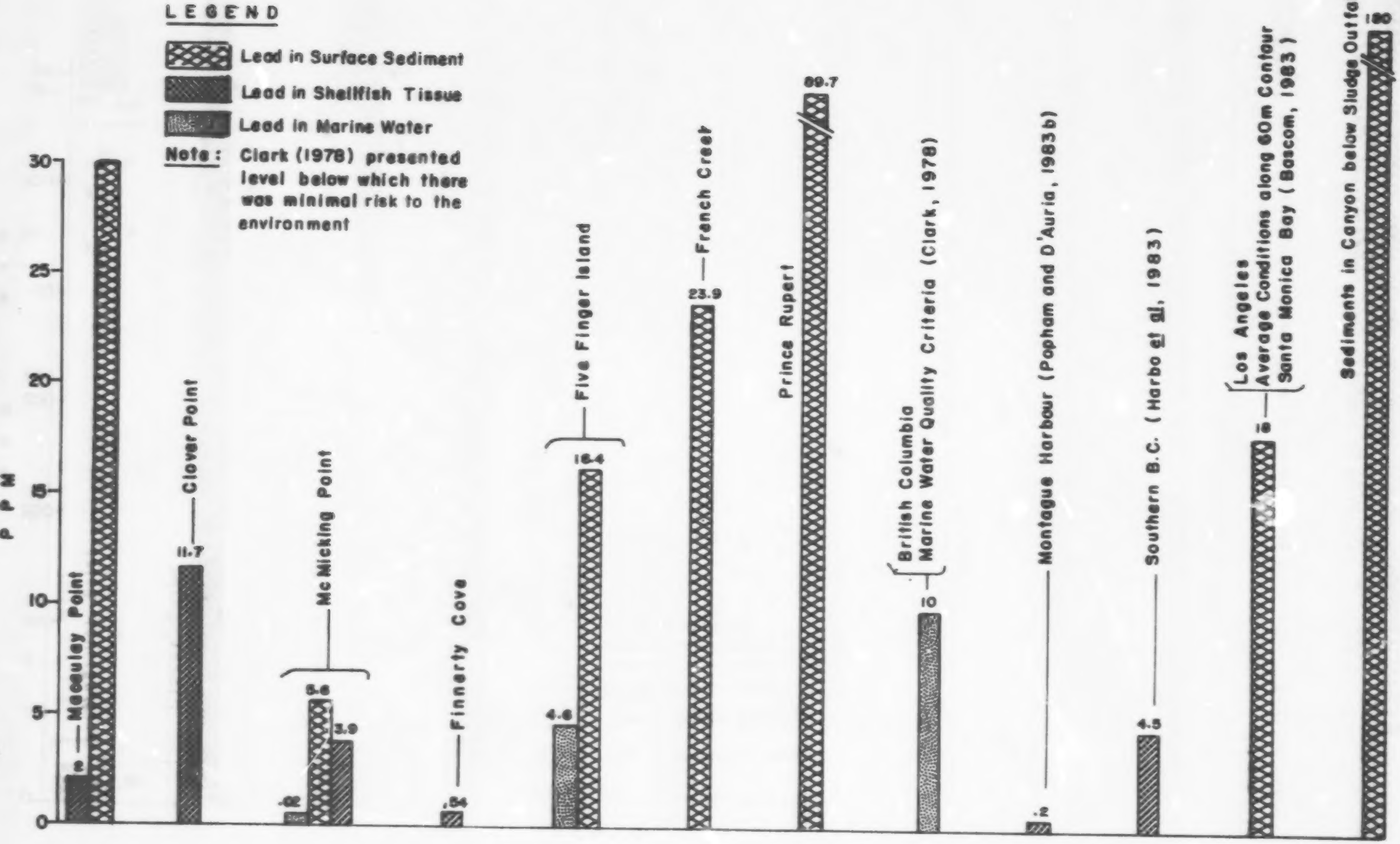

FIGURE 20 COMPARISON OF MEAN LEAD CONCENTRATIONS IN MARINE WATER, SURFACE SEDIMENT AND SHELLFISH TISSUE FOR SELECTED OUTFALL AREAS

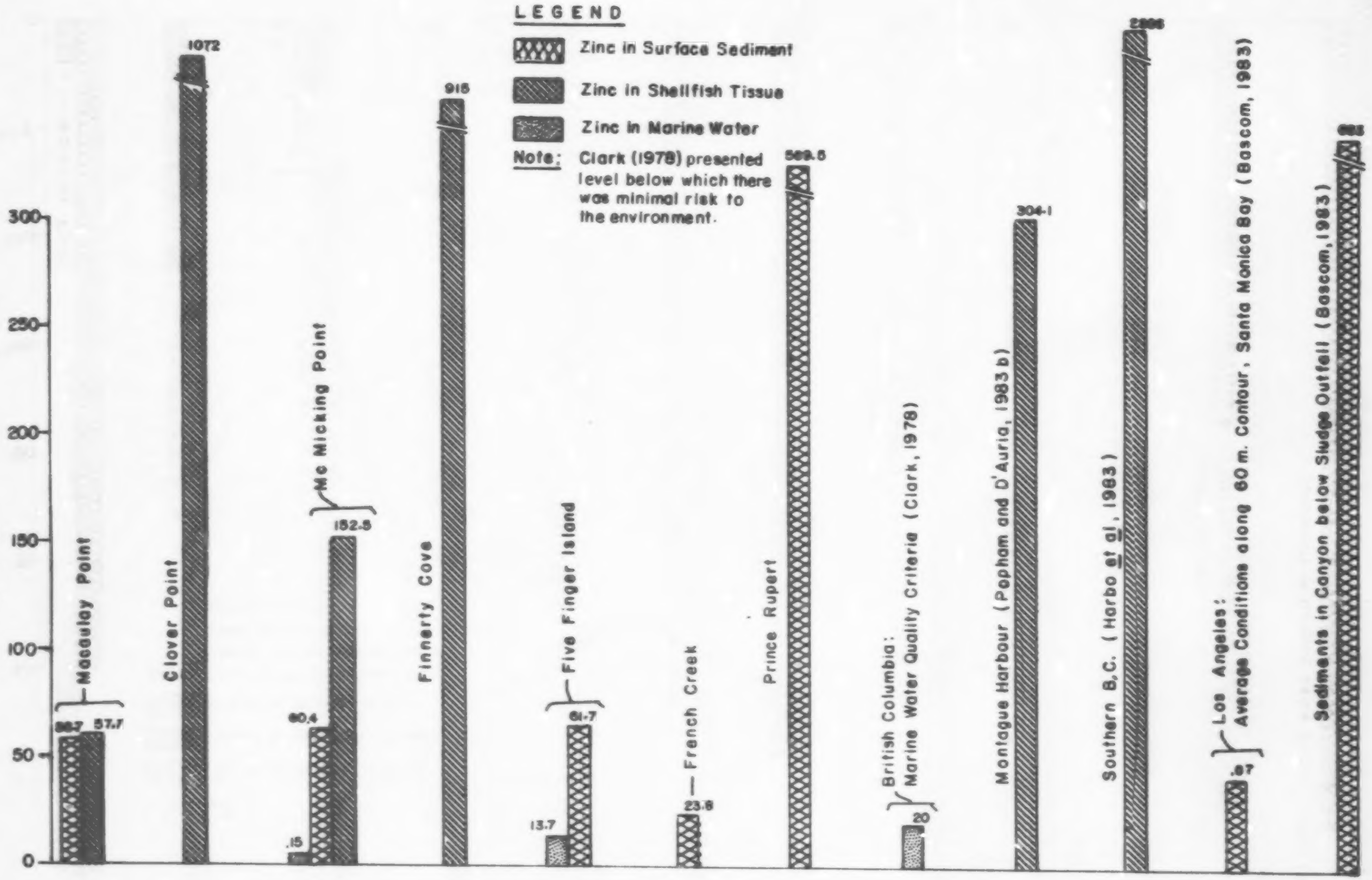

FIGURE 21 COMPARISON OF MEAN ZINC CONCENTRATIONS IN MARINE WATER, SURFACE SEDIMENT AND SHELLFISH TISSUE FOR SELECTED OUTFALL AREAS

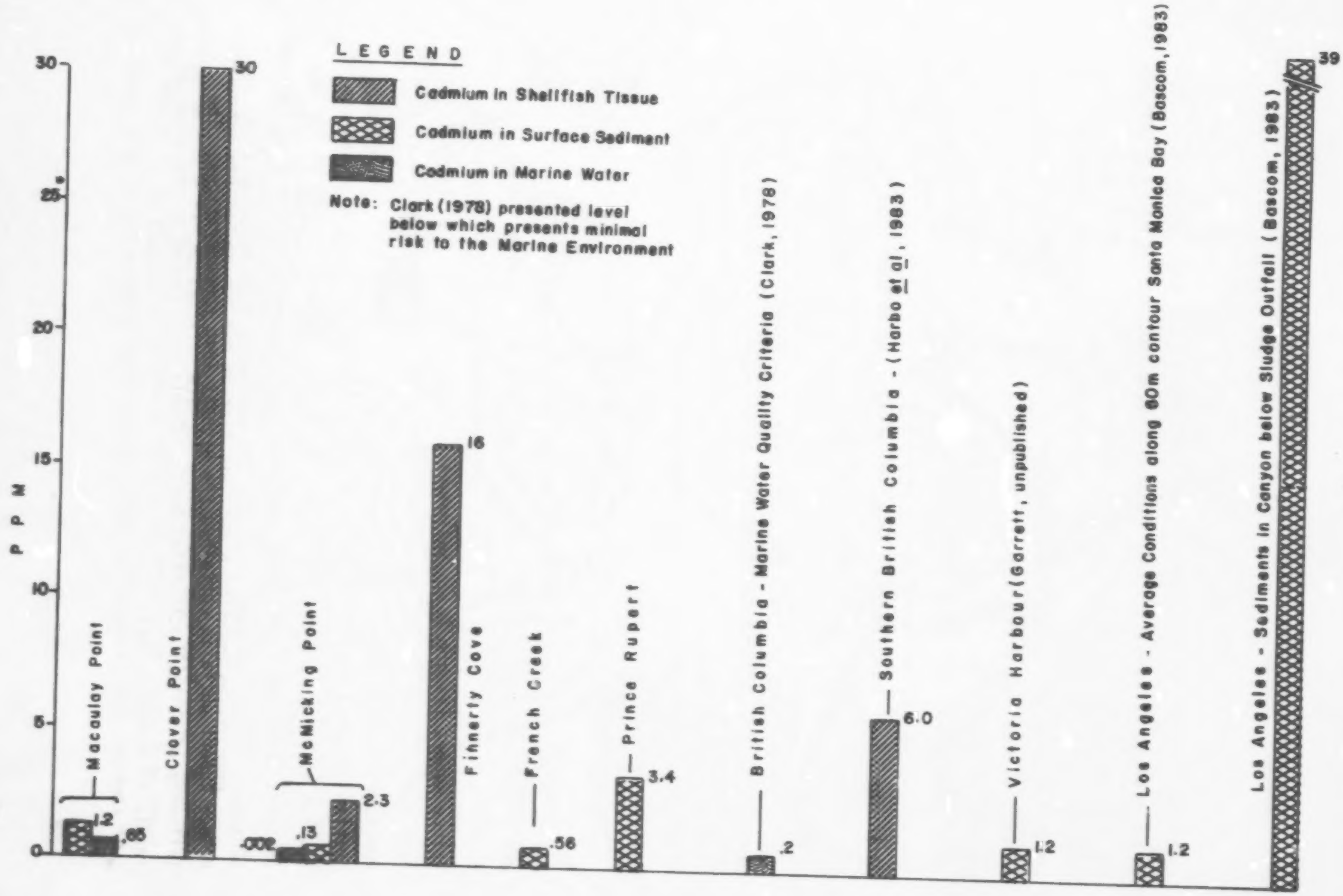

FIGURE 22 COMPARISON OF MEAN CADMIUM CONCENTRATIONS IN MARINE WATER, SURFACE SEDIMENT AND SHELLFISH TISSUE FOR SELECTED OUTFALL AREAS

exceeded 1.0 ppm but did reach concentrations of 5.5 ppm (Table 18). But as Garrett et al (1980) noted, sediment concentrations between 0.1 ppm and 1.0 ppm may indicate naturally high background levels of mercury and/or contamination as a result of industrial or other man-related releases. As seen in Figure 18, Prince Rupert Harbour showed the highest levels of mercury in sediment for the selected outfall areas with a mean mercury concentration 0.9 ppm. According to Figure 18, Victoria Harbour was the only location of the sites considered in the illustration where the mercury concentration was above 1.0 ppm. Garrett et al (1980) reported 1.0 ppm marks the level above which further investigation is warranted because of the associated high levels of mercury found in the tissue of aquatic organisms.

Sediment analysis has the advantage of indicating the cumulative effect of marine discharges (Chapman, 1979) however the difficulty of determining the sources of contaminants still remains. The fact that the metal content of sediment is dependent upon particle size (Pomeroy, 1982) must be taken into account.

A noted trend amongst sediment data is elevated levels of copper and lead in sediments particularly from areas adjacent to the Macaulay Point, McMicking Point, French Creek and Prince Rupert outfalls (Figures 19 and 20). Concentrations of copper in sediment surrounding the mentioned outfalls range from values of 9.4 ppm at French Creek to 505.0 ppm at Prince Rupert (Figure 18). Sediments surrounding a Los Angeles outfall have contained up to 782 ppm while Puget Sound sediments contain 11 to 870 ppm copper. Similarly, lead concentrations in sediments adjacent to British Columbia outfall areas (5.6 ppm at McMicking Point to a maximum of 365 ppm at Prince Rupert) are below Los Angeles records of 180 to 537 ppm (Bascom, 1983) and Puget Sound sediment lead concentrations of 8 to 800 ppm (Chapman, 1979). As seen in Figure 20, sediments from Macaulay Point and Prince Rupert outfalls contained the highest lead concentrations. The influence of harbour activities most probably contributed to the elevated levels in Prince Rupert.

Copper is one of at least eleven heavy metals which are natural constituents of the marine environment and which are biologiclly essential (Bryan, 1980). At high levels, it is toxic and is bioaccumulated (Chapman, 1979) and therefore, like zinc and other essential metals, must be considered a potential contaminant of marine organisms. It is interesting to note that metals in sediment which are 10 to 100 times background levels may have sublethal effects on small invertebrates but are seldom found in tissues of larger invertebrates (Bascom, 1983).

From all appearances, the Macaulay Point outfall is the source of elevated copper and lead levels (Goyette *et al*, 1982). Metal levels in the Prince Rupert Harbour most likely originate from a variety of industrial sources. It is difficult to estimate the contribution of metals to the marine environment which are made by municipal sewage outfalls. Schell (1976) suggested the METRO Seattle sewage outfall was not the major source of metals in Puget Sound.

Marine organisms are often used as indicators of metal contamination, the accumulation of which is influenced by environmental and biological factions (Bryan, 1980). Although metals in solution are often in biologically available forms, it has been shown that the uptake of metals by marine fauna is dependent upon the composition of particles to which the metals are absorbed (Bryan, 1980). Some organisms reflect the environmental concentrations of metals better than others. For example, the mussel, *Mytilus edulis* excretes metal at a rate proportional to the body burden and therefore the concentration in the body is proportional to environmental availability (Bryan, 1980).

M. edulis are well recognized as valuable monitors of trace metal pollution of estuarine waters (Popham and D'Auria, 1983a). Application of statistical analysis to trace metals in mussels has been utilized to determine whether or not the mussels are from a polluted environment (Popham and D'Auria, 1983a). Without going into such detail, a comparison of metals in *M. edulis* collected at McMicking Point with those from other regions (Table 21) reveals local mussels have trace-metal body burdens in the range of areas receiving a combination of industrial and domestic wastes (Brown, McFarland, and Thomson, 1980) (see Figures 18 to 21).

Mercury and lead are considered hazardous metals to both marine organisms and man (Harbo et al, 1983). The highest level of lead in molluscs collected from areas relevant to this review were obtained from Clover Point (Table 5, Figure 20). The concentration of 11.7 ppm (dry weight) presented in Figure 20 was above the mean lead level of 4.5 ppm (dry weight) in molluscs as recorded by Harbo et al (1983) who collected samples adjacent to urban and industrial areas in Southern British Columbia. McMicking Point and Finnerty Cove outfalls discharged effluent which had a mercury content slightly higher than the British Columbia Ministry of the Environment recommended level (Stanley Associates, 1982). As shown in Figure 18, mercury in shellfish tissue from both outfalls was above the mean level in molluscs from southern British Columbia, as reported by Harbo et al (1983).

Zinc and copper levels in aquatic organisms are not considered hazardous to humans but they may have lethal or sublethal affects on the organisms (Harbo et al, 1983). The highest levels observed in molluscs in the areas considered were collected from the Clover Point and Finnerty Cove outfalls which had six to seven times greater copper, cadmium and zinc levels than for samples obtained from the McMicking Point outfall terminus (Table 12, 18 and 20)) (Stanley Associates, 1982). Although the levels of zinc presented by Stanley Associates (1982) appear high (845-915 ppm, dry weight), levels of 100-1000 ppm (dry weight) are not uncommon for bottom dwellers such as molluscs (Stanley Associates, 1982). The Pacific oyster (*Crassostrea gigas*) is known to concentrate zinc at higher levels than in most shellfish (Harbo et al, 1983). The mean dry weight contents of zinc in *C. gigas* taken from Southern British Columbia waters were recorded as 2886 ± 4117 ppm (Harbo et al, 1983). The Finnerty Cove mussel samples which contained between 845 and 915 ppm were therefore not extreme.

In summary, mean levels of mercury, lead, copper and cadmium in shellfish collected adjacent to outfalls considered in this review were above mean levels in molluscs obtained from waters close to urban and industrial areas in southern British Columbia (as reported by Harbo et al, 1983).

It is interesting to note that Popham and D'Auria (1983a) suggest that areas in British Columbia where mussels are found to have high concentrations of lead, zinc and copper are reflecting industrial pollution of the surrounding seawater. Also, some animal cells generate a protective protein which prevents excessive concentrations of metals from damaging enzyme systems and genetic tissues (Popham and D'Auria, 1983b).

A comparison of tissue metal levels in English sole (Parophrys vetulus) collected during trawls adjacent to the French Creek outfall between 1977 and 1980 (Table 21), show the zinc content of tissue increased by a factor of two (Pomeroy, 1982).

3.3 Organics

Organic substances, well known for their ability to accumulate to toxic levels without being degraded (FRES, 1979) have been detected in sediments and mussels adjacent to Macaulay Point and McMicking Point (Tables 3, 8 and 10). These ubiquitous pollutants are used in electrical equipment (PCBs) and as pesticides (dieldrin) and wood preservatives (hexachlorobenzene) (FRES, 1979). Exposure to toxic organic substances can elicit sublethal effects such as disruption of osmoregulation in marine teleosts and interference with ATPase enzymes in fish and shrimp (Garrett, 1983).

The amount of PCBs in Macaulay Point sediment is far below PCBs measured at marine sites at other British Columbia locations as recorded by Garrett (1983). Brown, McFarland, and Thomson (1980) and Stanley Associates (1982) noted that organic contaminants were found in higher sediment and mussel concentrations near the McMicking Point outfall terminus than at control sites. It was also found that organic

TABLE 21 CONCENTRATIONS OF TRACE METALS FOUND IN *Mytilus edulis* AROUND THE WORLD

References: Brown, MacFarland and Thomson, 1980.
Bryan, 1980.
Forstner and Whittman, 1979.

LOCATION	TRACE METAL CONCENTRATION (ppm)				
	Zn	Cd	Cu	Pb	Hg
East Looe Estuary Devon, England	113	2.3	9	45	0.39
New Zealand	31	10	9	12	-
Irish Sea	91	5.1	9.6	9.1	-
North Sea	-	-	-	-	0.1-0.29
St. Lawrence Estuary	-	-	-	-	0.16-0.629
Mediterranean (N.W. Coast)	209	1.9	18	21.5	-
Troudheimsfjorden Norway	169	2	24	-	-
McMicking Point	153-221	1.6-3.5	7.9-10.3	< 1.1-4.3	0.087-0.2

contaminants in mussels and sediments were higher than in sewage (Brown, McFarland, and Thomson, 1980). Whether or not there were sources of contaminants other than the sewage outfall was not been determined. McMicking Point sediment PCB levels were below the median range of sediment samples collected throughout British Columbia as reported by Garrett (1983).

3.4 Effects of Domestic Waste on the Species Composition of Marine Communties

The use of marine invertebrates or populations as indicators of pollution is based on the belief that natural, unpolluted environments are characterized by balanced biological conditions which display a great diversity of plant and animal life (Pike and Gameson, 1970; Reish, 1972; McIntyre and Johnson, 1974; Pearson, 1981). The consequences of environmental stress have been observed through changes in structure and diversity of marine communities and through sublethal effects which are expressed in terms of histological, morphological or ethological responses of marine organisms (Pearson, 1981; Rosenthal and Alderdice, 1976).

Benthic communities have been used to identify changed and degraded environmental conditions as most organisms making up the communities spend their life in the same area, have short life cycles and they respond rapidly to changes which may otherwise be undetectable (Word, 1978). Therefore, not only do they reflect conditions at the time of sampling, but also conditions for some time previously (Reish, 1972). Periodic monitoring of benthos in the vicinity of domestic outfall sewers in California has demonstrated that if the amount of discharge is large, then the amount of effected area is directly related to the quantity of discharge (Reish, 1972). The stability of benthic communities in the Macaulay Point (Balch *et al*, 1976; Goyette, unpublished) and French Creek (Pomeroy, 1982) outfall areas suggested the impact of sewage effluent on the marine environments was slight. On the other hand, Ellis (1980a) noted a low diversitiy of faunal species in the immediate area of the McMicking Point outfall. This was supported by monitoring results of Ellis and

Emerson (1979) and Bierheuzen (1982) which suggest there was an impact on fauna within the vicinity of the pre-extended McMicking Point sewage outfall.

A typical benthic community was observed around the Five Finger Island outfall (Packman, 1979) in the late 1970's but it was later recorded (Pomeroy and Packman, 1981) that the species composition around the outfall had changed. Despite this alteration, bottom samples did not exhibit characteristics of polluted communities (Pomeroy and Packman, 1981).

An increased concentration of fish (primarily rockfish) was observed around the Five Finger Island outfall (Pomeroy and Packman, 1981). Trawl catches have shown that some species are attracted to effluent discharge areas while others avoid regions of sewage outfalls (Carlisle, 1972). When used as a pollution indicator, the attraction or repulsion of fish to effluent showed Santa Monica Bay to be unaffected (Carlisle, 1972). Therefore, the increase in rockfish around the Five Finger Island outfall should be noted but should not elicit serious ecological consequences.

3.5 Sublethal Effects of Contaminants on Marine Organisms

Varieties of crabs, clams, salmon and other commercially harvested organisms utilize receiving waters covered in this review as rearing and feeding areas and as migratory pathways. They are therefore subject to potentially harmful contaminants which are present in some areas of the Juan de Fuca and Georgia Straits. Sublethal effects although subtle, may cause cumulative chronic responses (Pequegnat and Wastler, 1980). For example, pollutants which bioaccumulate in the ovaries and gonadal tissue may affect fertilization of eggs, survival rates of hatchability and posthatching development (Rosenthal and Alderdice, 1976) which may in turn have consequences of ecological significance.

If high levels of a contaminant are found in routine monitoring of a receiving environment, it would seem appropriate to initiate testing for sublethal effects on major indicator species.

The McMicking Point outfall is a case in point. Elevated levels of metals (particularly mercury, zinc and copper) in sediments and mussels which were observed in pre-extension monitoring (Brown, McFarland, and Thompson, 1980; Ellis and Gee, 1981; Stanley Associates, 1982) suggest they may have caused the degeneration of mussel tissue noted by Ellis and Gee (1981). In this case, examination of sublethal responses may have been used to determine more precisely the effects on the individual mussels and on the local ecosystem.

The waters in and around the Prince Rupert Harbour support a valuable fishery resource. Crabs and clams are common in the area while eelgrass beds near Frederick Point sustain winter feeding of chinook salmon and provide rearing ares for juvenile salmon (EPS Memorandum, 1979). The harbour is a migration route for adults and juvenile salmon and has been a herring spawning ground (EPS Memorandum, 1979).

The Prince Rupert Harbour helps sustain the local fishing industry and acts as a dumping ground for waste products of the fish processing plant, grain terminal and boat yards. The contaminants released into the marine environment by light industry do not appear to threaten marine life but the possibility of metals causing sublethal effects in commercially valuable species should be recognized.

Sublethal studies of marine organisms is a receiving environment monitoring option available to administrators of monitoring programs. The question to be reckoned with is whether or not such detailed analysis is warranted in receiving environments of marine municipal outfalls of British Columbia.

3.6 Overview of the Selected Receiving Environment Monitoring Programmes

A large portion of the information collated in this review was collected from government agencies and researchers associated with the management of monitoring programs for marine municipal outfalls located in Victoria and the surrounding areas (the CRD). The authority responsible for assessment of operating domestic outfalls in the CRD is the municipality which reports raw data to the regional WMB. As a central information centre, the WMB stores data on its computer data system EQUIS. The system was checked for completeness and accuracy for the period 1970-1979 by Hoff (1981) however, data covering monitoring between 1979 and 1982 is in its original state. Vassos (1982a) noted that sampling dates in years 1973-1979 were not consistent. Thus, questions are raised concerning the accuracy and validity of data recorded on EQUIS. The Provincial Government is in the process of renovating its computer storage system. SEAM (System for Environmental Assessment and Management) will provide similar services to EQUIS and is expected to come into operation in 1985 (A. Teasdale, pers. comm.). A concise review of monitoring conducted around Victoria since 1970 outlines institutional framework and the extent of monitoring of major outfalls (Ellis, 1984).

Routine monitoring of receiving environments being carried out at present is done in order to fulfill permit requirements and is therefore done by the permittee. For outfalls serving Victoria, the Saanich Peninsula and Nanaimo, data is collected for coliform and physical parameters. Municipal outfalls serving Campbell River, Prince Rupert, Powell River, and the Lions Gate outfall are not involved in any receiving environment monitoring schemes.

Bacterial studies and treatment plant tests (Ellis, 1976; Kay, 1980; Stanley Associates, 1982) suggest the Finnerty Cove and East Saanich Peninsula domestic waste disposal systems are the cause of poor water quality. There are additional problems in the Cadboro Bay and Oak Bay areas associated with continual use of sewage outfalls which were intended for wet weather overflows only. The Greater Victoria East Coast Sewerage Study (1983) addresses these problems and suggests options involving diverting flows from Finnerty Cove and area, and McMicking Point to the Clover Point outfall. In light of this proposal, a review of the Clover Point monitoring program is underway. It is anticipted that the current program will be revised with consideration given to the suggestions put forward by J.E. Anderson Associates (Vassos, 1982a and b; John Finnie, pers. comm.).

The Federal Government has, in some cases, conducted sampling of municipal outfall receiving environments. Unless monitoring is required by the Permit, the cost of such programmes deters the municipality from carrying out extensive monitoring. When the EPS feels there is a need for receiving water monitoring (as in the case of French Creek), it exercises its right under the Federal Fisheries Act, to conduct a marine municipal outfall receiving environment monitoring programme.

A question which evolved from the proposal to almost double the flow of domestic waste from the Clover Point outfall concerns the question of the assimilative capacity of the receiving environment. Estimations of quantities of nutrients and contaminants which can be effectively incorporated in a marine ecosystem must take into account the effects on all structural elements of the system. From this review, it appears authorities have a fair collection of raw data reflecting levels of nutrients and contaminants in various components of the marine ecosystem. By gathering together major components, the collective effects of the contaminants can be utilized to look at the situation from an ecological perspective. In this way, scientists will be in a better position to predict the assimilative capacity of marine ecosystems.

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APPENDIX I

SUMMARY OF WATER QUALITY NUTRIENT DATA FOR THE MACAULAY POINT MARINE MUNICIPAL OUTFALL

APPENDIX I

TABLE 1 NUTRIENT DATA Adapted from Hoff (1981), EQUIS, Vassos (1982a) and WMB (1982)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

AMMONIA (ppm)

DATA SOURCE:		HOFF (1981)				EQUIS				VASSOS (1982a)				WMB (1982)			
SAMPLING	DEPTH*	1976 - 1979				1977 - 1979				1977 - 1979				JAN. - DEC. 1981			
STATION	(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0		0.019			28	0.019	0.009	0.041	28	0.019	0.011	0.032	9	0.020	0.009	0.034
S2	0		0.016			28	0.016	0.006	0.033	28	0.016	0.010	0.027	9	0.016	0.004	0.024
S3	0		0.029			28	0.028	0.001	0.148	28	0.028	0.007	0.091	9	0.017	0.003	0.028
S4	0		0.018			28	0.018	0.007	0.045	28	0.018	0.011	0.031	9	0.019	0.012	0.030
S5			0.016														
W1	0		0.018			26	0.018	0.005	0.084	26	0.017	0.0	0.037				
W2	all		0.014			26	0.015	0.004	0.038	31	0.015	0.007	0.027				
W3	0		0.015			26	0.015	0.004	0.031	26	0.014	0.005	0.026				
W4	0		0.015			26	0.015	0.004	0.034	26	0.015	0.006	0.027				
W5	0		0.015			26	0.015	0.005	0.033	26	0.014	0.007	0.027	9	0.015	0.005	0.024
W6	0		0.015			26	0.015	0.007	0.036	28	0.015	0.009	0.027				
W7	0		0.014			26	0.015	0.004	0.036	26	0.014	0.006	0.027				
W8	0		0.015			26	0.015	0.004	0.034	26	0.014	0.006	0.026				
W9	0		0.014			26	0.014	0.004	0.034	26	0.014	0.007	0.026				
J1	all					5	0.012	0.008	0.038	5	0.018	0.0	0.154				
J2	all					5	0.020	0.007	0.041	5	0.018	0.0	0.147				

*Taken from Equis

Continued...

APPENDIX I

TABLE 1 NUTRIENT DATA Adapted from Hoff (1981), EQUIS, Vassos (1982a) and WMB (1982)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

(Continued)

NITRITE (ppm)

DATA SOURCE:		HOFF (1981)				EQUIS				VASSOS (1982a)				WMB (1982)			
SAMPLING	DEPTH*	1976 - 1979				1970 - 1979				1977 - 1979				JAN. - DEC. 1981			
STATION	(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0		0.004			100	0.004	0.002	0.008	65	0.004	0.003	0.005	9	0.004	0.001	0.006
S2	0		0.004			100	0.004	0.001	0.007	65	0.004	0.003	0.005	9	0.004	0.001	0.005
S3	0		0.004			100	0.004	0.002	0.016	65	0.004	0.002	0.005	9	0.003	0.002	0.005
S4	0		0.004			97	0.004	0.002	0.006	63	0.004	0.003	0.005	9	0.004	0.002	0.005
S5			0.004														
W1	0		0.004			96	0.004	0.001	0.009	63	0.004	0.002	0.005				
W2	all		0.004			113	0.004	0.001	0.015	71	0.003	0.002	0.005				
W3	0		0.004			97	0.004	0.001	0.006	63	0.003	0.002	0.005				
W4	0		0.004			97	0.004	0.001	0.010	63	0.003	0.002	0.005				
W5	0		0.004			98	0.004	0.001	0.008	63	0.003	0.002	0.005				
W6	0		0.004			96	0.004	0.001	0.010	61	0.003	0.002	0.004	9	0.003	0.001	0.005
W7	0		0.004			98	0.003	0.001	0.006	63	0.003	0.002	0.005				
W8	0		0.004			98	0.003	<0.001	0.007	63	0.003	0.002	0.005				
W9	0		0.004			98	0.004	0.001	0.006	63	0.003	0.002	0.005				
J1	all					18	0.004	0.001	0.005	9	0.004	0.0	0.011				
J2	all					17	0.004	0.002	0.006	7	0.004	0.0	0.016				

Continued...

*Taken from Equis

APPENDIX I

TABLE 1 NUTRIENT DATA Adapted from Hoff (1981), EQUIS, Vassos (1982a) and WMB (1982)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

(Continued)

NITRATE (ppm)

DATA SOURCE:		HOFF (1981)				EQUIS				VASSOS (1982a)				WMB (1982)			
SAMPLING	DEPTH*	1976 - 1979				1972 - 1976				1977 - 1979				JAN. - DEC. 1981			
STATION	(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0		0.280			43	0.267	0.065	0.380	65	0.280	0.205	0.356	8	0.280	0.181	0.375
S2	0		0.303			43	0.280	0.045	0.383	65	0.305	0.241	0.371	9	0.304	0.222	0.367
S3	0		0.302			43	0.292	0.110	0.384	65	0.304	0.213	0.367	9	0.296	0.229	0.371
S4	0		0.277			42	0.259	0.023	0.407	63	0.278	0.126	0.363	9	0.270	0.190	0.357
S5			0.308														
W1	0		0.318			42	0.306	0.126	0.383	63	0.319	0.257	0.374				
W2	all		0.316			52	0.303	0.128	0.388	70	0.315	0.259	0.371				
W3	0		0.313			42	0.306	0.199	0.388	63	0.313	0.259	0.371				
W4	0		0.317			42	0.306	0.199	0.383	63	0.316	0.253	0.373				
W5	0		0.314			43	0.300	0.133	0.379	63	0.316	0.257	0.371				
W6	0		0.311			43	0.295	0.134	0.383	61	0.311	0.229	0.365	9	0.302	0.204	0.378
W7	0		0.317			43	0.306	0.208	0.383	63	0.316	0.262	0.372				
W8	0		0.315			43	0.296	0.132	0.362	63	0.317	0.261	0.375				
W9	0		0.308			43	0.287	0.104	0.378	63	0.310	0.250	0.367				
J1	all					11	0.316	0.231	0.421	9	0.284	0.0	0.845				
J2	all					12	0.312	0.205	0.428	7	0.273	0.0	0.699				

*Taken from Equis

Equis all = 0 m, 3.99 m, 25 m, 50 m, 75 m

Continued...

APPENDIX I

TABLE 1 NUTRIENT DATA Adapted from Hoff (1981), EQUIS, Vassos (1982a) and WMB (1982)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

(Continued)

PHOSPHATE (ppm)

DATA SOURCE:		HOFF (1981)				EQUIS				VASSOS (1982a)				WMB (1982)			
SAMPLING	DEPTH*	1976 - 1979				(Total Orthophosphate) 1972-1977				1977 - 1979				JAN. - DEC. 1981			
STATION	(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0		0.057			21	0.058	0.023	0.071	65	0.057	0.041	0.070	9	0.059	0.035	0.077
S2	0		0.059			21	0.061	0.051	0.071	65	0.059	0.042	0.072	9	0.062	0.042	0.078
S3	0		0.063			21	0.062	0.042	0.089	65	0.062	0.045	0.075	9	0.061	0.043	0.077
S4	0		0.059			21	0.057	0.024	0.071	63	0.059	0.040	0.071	9	0.595	0.042	0.076
S5			0.060														
W1	0		0.061			19	0.062	0.054	0.071	63	0.061	0.046	0.072				
W2	all		0.061			22	0.061	0.053	0.072	70	0.061	0.045	0.073				
W3	0		0.060			19	0.061	0.053	0.071	63	0.060	0.046	0.072				
W4	0		0.060			19	0.062	0.054	0.071	63	0.061	0.046	0.072				
W5	0		0.060			19	0.062	0.053	0.071	63	0.060	0.045	0.072				
W6	0		0.060			21	0.062	0.053	0.072	61	0.060	0.043	0.072	9	0.061	0.040	0.077
W7	0		0.061			19	0.062	0.053	0.071	63	0.061	0.046	0.072				
W8	0		0.061			19	0.062	0.053	0.072	63	0.061	0.048	0.072				
W9	0		0.060			19	0.061	0.040	0.071	63	0.060	0.045	0.071				
J1	all					3	0.055	0.052	0.059	9	0.057	0.0	0.148				
J2	all					3	0.057	0.054	0.061	7	0.056	0.0	0.134				

*Taken from Equis

Continued...

APPENDIX I

TABLE 2 NUTRIENT DATA Adapted from Balch _et_ _al_ (1976) and WMB (1982)
Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

AMMONIA (ppm)

DATA SOURCE:		GOYETTE ET AL (unpublished)			
SAMPLING STATION	DEPTH (m)	JUNE 1979			
		No. of Values	Mean	Min.	Max.
Point of Discharge	0 - 10	4	0.015	0.015	0.015
	25 - 50	2	0.025	0.018	0.033
Line 1, Arc 1	0 - 10	4	0.012	0.011	0.012
	25 - 50	2	0.018	0.015	0.020
Line 2, Arc 2	0 - 10	4	0.016	0.014	0.018
	25 - 46	2	0.015	0.014	0.016
Line 3, Arc 1	0 - 10	4	0.018	0.014	0.020
	25 - 50	2	0.014	0.014	0.014
Line 5, Arc 1	0 - 10	4	0.015	0.014	0.017
	25 - 50	2	0.017	0.017	0.018
Line 7, Arc 2	0 - 10	4	0.014	0.013	0.018
	25 - 50	2	0.016	0.014	0.019
Line 7, Arc 2	0 - 10	4	0.015	0.014	0.019
	25 - 46	2	0.018	0.018	0.018

Continued...

APPENDIX I

TABLE 2 NUTRIENT DATA Adapted from Balch et al (1976) and WMB (1982)
Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source
(Continued)

NITRITE (ppm)

DATA SOURCE:		BALCH E T A L (1976)						GOYETTE ET AL (unpublished)			
SAMPLING STATION	DEPTH* (m)	MAY 1970 - OCT. 1972				SAMPLING STATION	DEPTH (m)	June 1979			
		No. of Values	Mean	Min.	Max.			No. of Values	Mean	Min.	Max.
S1	0					Point of	0 - 10	4	0.005	0.005	0.005
S2	0					Discharge	25 - 50	2	0.005	< 0.005	0.005
S3	0	33	0.004	0.002	0.006	Line 1, Arc 1	0 - 10	4	0.005	< 0.005	0.005
S4	0						25 - 50	2	< 0.005	< 0.005	< 0.005
S5						Line 1, Arc 2	0 - 10	4	0.005	< 0.005	0.005
W1	0						25 - 46	2	< 0.005	< 0.005	< 0.005
W2	all					Line 3, Arc 1	0 - 10	4	< 0.005	< 0.005	< 0.005
W3	0						25 - 50	2	< 0.005	< 0.005	< 0.005
W4	0	32	0.004	0.002	0.007	Line 5, Arc 1	0 - 10	4	< 0.005	< 0.005	< 0.005
W5	0						25 - 50	2	< 0.005	< 0.005	< 0.005
W6	0					Line 7, Arc 1	0 - 10	4	0.005	< 0.005	0.005
W7	0						25 - 50	2	0.005	0.005	0.005
W8	0					Line 7, Arc 2	0 - 10	4	< 0.005	< 0.005	< 0.005
W9	0						25 - 46	2	< 0.005	< 0.005	< 0.005
J1	all	5	0.004	0.002	0.005						
J2	all										

*Taken from Equis

Continued...

APPENDIX I

TABLE 2 NUTRIENT DATA Adapted from Balch *et al* (1976) and WMB (1982)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source (Continued)

NITRATE (ppm)

DATA SOURCE:		BALCH ET AL (1976)						GOYETTE ET AL (unpublished)			
		MAY 1970 - OCT. 1972						June 1979			
SAMPLING STATION	DEPTH* (m)	No. of Values	Mean	Min.	Max.	SAMPLING STATION	DEPTH (m)	No. of Values	Mean	Min.	Max.
S1	0					Point of	0 - 10	4	0.314	0.294	0.327
S2	0					Discharge	25 - 50	2	0.298	0.268	0.310
S3	0	35	0.25	0.10	0.36	Line 1, Arc 1	0 - 10	4	0.241	0.222	0.261
S4	0						25 - 50	2	0.298	0.250	0.345
S5						Line 1, Arc 2	0 - 10	4	0.314	0.306	0.322
W1	0						25 - 46	2	0.276	0.263	0.288
W2	all					Line 3, Arc 1	0 - 10	4	0.323	0.298	0.353
W3	0						25 - 50	2	0.269	0.267	0.270
W4	0	33	0.300	0.170	0.375	Line 5, Arc 1	0 - 10	4	0.331	0.285	0.378
W5	0						25 - 50	2	0.350	0.340	0.361
W6	0					Line 7, Arc 1	0 - 10	4	0.263	0.225	0.280
W7	0						25 - 50	2	0.306	0.292	0.320
W8	0					Line 7, Arc 2	0 - 10	4	0.276	0.253	0.288
W9	0						25 - 46	2	0.305	0.302	0.308
J1	all	5	0.320	0.225	0.380						
J2	all										

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*Taken from Equis

Continued...

APPENDIX I

TABLE 2 NUTRIENT DATA Adapted from Balch et al (1976) and WMB (1982)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

(Continued)

PHOSPHATE (ppm)

DATA SOURCE:		BALCH ET AL (1976)						GOYETTE ET AL (unpublished)			
		MAY 1970 - OCT. 1972						June 1979			
SAMPLING STATION	DEPTH* (m)	No. of Values	Mean	Min.	Max.	SAMPLING STATION	DEPTH (m)	No. of Values	Mean	Min.	Max.
S1	0					Point of Discharge	0 - 10	4	0.065	0.062	0.066
S2	0						25 - 50	2	0.062	0.060	0.064
S3	0	33	0.065	0.025	0.085	Line 1, Arc 1	0 - 10	4	0.060	0.053	0.066
S4	0						25 - 50	2	0.061	0.055	0.067
S5						Line 1, Arc 2	0 - 10	4	0.064	0.058	0.070
W1	0						25 - 46	2	0.060	0.059	0.061
W2	all					Line 3, Arc 1	0 - 10	4	0.067	0.061	0.071
W3	0						25 - 50	2	0.030	0.006	0.054
W4	0	33	0.066	0.035	0.090	Line 5, Arc 1	0 - 10	4	0.067	0.061	0.071
W5	0						25 - 50	2	0.068	0.067	0.069
W6	0					Line 7, Arc 1	0 - 10	4	0.056	0.050	0.060
W7	0						25 - 50	2	0.063	0.062	0.064
W8	0					Line 7, Arc 2	0 - 10	4	0.058	0.053	0.060
W9	0						25 - 46	2	0.063	0.063	0.064
J1	all	5	0.065	0.050	0.080						
J2	all										

*Taken from Equis

APPENDIX II

SUMMARY OF WATER QUALITY NUTRIENT DATA FOR THE CLOVER POINT MARINE MUNICIPAL OUTFALL

APPENDIX II

TABLE 1 NUTRIENT DATA Adapted from Hoff (1981), Equis and Vassos (1982a)

Maximum, Minimim and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

DATA SOURCE:		HOFF (1981)				EQUIS				VASSOS (1982a)			
SAMPLING STATION	DEPTH (m)	1976 - 1979				1975 - 1979				1976 - 1979			
		No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
							NITRITE (ppm)						
S60 c S178	all		0.012			16	0.011	0.004	0.011	34	0.007	0.001	0.009
S61 c S180	"		0.004			16	0.001	0.003	0.009	33	0.004	0.002	0.006
S5 c	"		0.004			60	0.004	0.002	0.006	34	0.004	0.002	0.005
S6	"		0.005			71	0.008	0.003	0.030	34	0.005	0.003	0.007
S59 c S175	"		0.004			16	0.006	0.003	0.013	34	0.004	0.002	0.005
W10	"		0.004			61	0.003	0.001	0.006	32	0.004	0.002	0.005
W151 c W51	"		0.004			23	0.005	0.003	0.007	36	0.004	0.002	0.005
W152 c W52	"		0.003			18	0.004	0.004	0.006	36	0.004	0.002	0.005
W153 c W53	"		0.003			21	0.005	0.003	0.007	36	0.004	0.002	0.005
W154 c W54	"		0.003			16	0.004	0.003	0.006	35	0.004	0.002	0.005
W155 c W55	"		0.003			16	0.004	0.003	0.006	36	0.004	0.002	0.005
W156 c W56	"		0.003			11	0.006	0.003	0.008	32	0.004	0.002	0.005
W157 c W57	"		0.003			11	0.006	0.003	0.007	31	0.003	0.002	0.005
W158 c W58	"		0.003			11	0.006	0.003	0.008	32	0.003	0.002	0.005
							PHOSPHATE (ppm)						
S60 c S178	all		0.269			44	0.270	0.050	0.922	34	0.248	0.0	0.599
S61 c S180	"		0.061			43	0			33	0.062	0.054	0.071
S5 c	"		0.060			34	0.061	0.037	0.071	34	0.061	0.043	0.078
S6	"		0.147			44	0.254	0.043	3.160	34	0.148	0.057	0.360
S59 c S175	"		0.062			44	0.067	0.052	0.185	34	0.063	0.056	0.071
W10	"		0.061			32	0.061	0.033	0.071	22	0.061	0.044	0.077
W151	"		0.062			67	0.062	0.044	0.072	60	0.062	0.056	0.070
W152	"		0.063			62	0.061	0.051	0.073	60	0.062	0.057	0.071
W153	"		0.061			65	0.061	0.037	0.072	60	0.061	0.054	0.071
W154	"		0.061			59	0.061	0.044	0.071	59	0.061	0.054	0.068
W155	"		0.061			60	0.061	0.040	0.071	60	0.062	0.054	0.070
W156	"		0.062			39	0.062	0.040	0.073	32	0.062	0.055	0.071
W157	"		0.062			38	0.062	0.043	0.071	31	0.062	0.055	0.071
W158	"		0.061			39	0.061	0.038	0.071	32	0.061	0.044	0.077

c = corresponds with

Continued...

APPENDIX II
TABLE 1 NUTRIENT DATA Adapted from Hoff (1981), Equis and Vassos (1982a)
Maximum, Minimim and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source
(Continued)

DATA SOURCE:		HOFF (1981)				EQUIS				VASSOS (1982a)			
SAMPLING	DEPTH	1976 - 1979				1975 - 1979				1976 - 1979			
STATION	(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max	No. of Values	Mean	Min.	Max.
							NITRATE (ppm)						
S60 c S178	all		0.302			10	0.328	0.120	0.50	33	0.315	0.259	0.364
S61 c S180	"		0.315			10	0.330	0.270	0.40	32	0.317	0.257	0.367
S5 c	"		0.308			24	0.301	0.156	0.37	33	0.312	0.262	0.371
S6	"		0.307			35	0.306	0.020	0.54	33	0.309	0.253	0.356
S59 c S175	"		0.320			10	0.337	0.270	0.43	33	0.323	0.287	0.367
W10	"		0.319			24	0.313	0.224	0.38	31	0.321	0.262	0.365
W151 c W51	"		0.321			7	0.339	0.300	0.39	35	0.320	0.282	0.368
W152 c W52	"		0.321			2	0.365	0.340	0.39	35	0.324	0.286	0.369
W153 c W53	"		0.320							35	0.320	0.270	0.368
W154 c W54	"		0.321							34	0.320	0.271	0.366
W155 c W55	"		0.320			7	0.340	0.320	0.39	35	0.321	0.270	0.369
W156 c W56	"		0.322			7	0.340	0.310	0.39	31	0.322	0.273	0.367
W157 c W57	"		0.321			7	0.340	0.310	0.39	30	0.323	0.279	0.370
W158 c W58	"		0.003			11	0.006	0.003	0.00	31	0.323	0.273	0.363
							AMMONIA (ppm)				(1977 - 1979)		
S60 c S178	all		1.041			28	0.976	0.011	3.72	28	0.972	0.107	2.590
S61 c S180	"		0.018			27	0.019	0.004	0.04	27	0.019	0.010	0.028
S5 c	"		0.016			28	0.018	0.006	0.04	28	0.018	0.010	0.031
S6	"		0.304			28	0.284	0.010	1.88	28	0.290	0.033	1.197
S59 c S175	"		0.017			28	0.019	0.006	0.05	28	0.019	0.010	0.032
W10	"		0.015			28	0.016	0.003	0.03	26	0.015	0.007	0.027
W151 c W51	"		0.014			54	0.019	0.004	0.01	30	0.015	0.007	0.027
W152 c W52	"		0.014			54	0.019	0.004	0.03	30	0.015	0.007	0.027
W153 c W53	"		0.013			54	0.020	0.004	0.06	30	0.015	0.007	0.027
W154 c W54	"		0.014			53	0.019	0.004	0.03	29	0.015	0.008	0.025
W155 c W55	"		0.014			54	0.019	0.004	0.03	30	0.015	0.007	0.027
W156 c W56	"		0.015			26	0.016	0.005	0.03	26	0.016	0.008	0.028
W157 c W57	"		0.014			25	0.014	0.004	0.02	25	0.014	0.007	0.025
W158 c W58	"		0.014			26	0.015	0.004	0.03	26	0.015	0.007	0.028

c = corresponds with

APPENDIX II
TABLE 2 NUTRIENT DATA Adapted from Balch *et al* (1976) and WMB (1982)
Maximum, Minimim and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

DATA SOURCE:		W M B (1 9 8 2)				B A L C H E T A L (1 9 7 6)			
		JAN. - NOV. 1981				FEB. 1971 - OCT. 1971			
SAMPLING STATION	DEPTH (m)	No. of Values	Mean	Min.	DEPTH (m)	No. of Values	Mean	Min.	Max.
				NITRITE (ppm)					
S60 c S178	all	10	0.010	0.004					
S61 c S180	"	10	0.003	0.001					
S5 c	"	10	0.003	0.002					
S6	"	10	0.003	0.001	0	24	0.008	0.003	0.021
S59 c S175	"	10	0.003	0.001					
W10	"								
W151 c W51	"								
W152 c W52	"								
W153 c W53	"								
W154 c W54	"								
W155 c W55	"								
W156 c W56	"								
W157 c W57	"								
W158 c W58	"								
				PHOSPHATE (ppm)					
S60 c S178	all	10	0.379	0.059					
S61 c S180	"	10	0.061	0.041					
S5 c	"	10	0.062	0.039					
S6	"	10	0.064	0.038	0	24	0.170	0.070	0.500
S59 c S175	"	10	0.064	0.051					
W10	"								
W151	"								
W152	"								
W153	"								
W154	"								
W155	"								
W156	"								
W157	"								
W158	"								

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c̄ corresponds with

Continued...

APPENDIX II
TABLE 2

NUTRIENT DATA Adapted from Balch et al (1976) and WMB (1982)
Maximum, Minimim and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source
(Continued)

DATA SOURCE:		WMB (1982)					BALCH ET AL (1976)			
SAMPLING STATION	DEPTH (m)	JAN. - NOV. 1981				DEPTH (m)	FEB. 1971 - OCT. 1971			
		No. of Values	Mean	Min.	Max.		No. of Values	Mean	Min.	Max.
					NITRATE (ppm)					
S60 c S178	all	10	0.300	0.214	0.377					
S61 c S180	"	10	0.306	0.213	0.366					
S5 c	"	10	0.299	0.206	0.373					
S6	"	10	0.309	0.193	0.370	0	22	0.288	0.125	0.390
S59 c S175	"	10	0.311	0.259	0.874					
W10	"									
W151 c W51	"									
W152 c W52	"									
W153 c W53	"									
W154 c W54	"									
W155 c W55	"									
W156 c W56	"									
W157 c W57	"									
W158 c W58	"									
					PHOSPHATE (ppm)					
S60 c S178	all	10	1.245	0.024	1.987					
S61 c S180	"	10	0.018	0.008	0.028					
S5 c	"	10	0.017	0.005	0.032					
S6	"	10	0.015	0.002	0.025					
S59 c S175	"	10	0.018	0.004	0.027					
W10	"									
W151 c W51	"									
W152 c W52	"									
W153 c W53	"									
W154 c W54	"									
W155 c W55	"									
W156 c W56	"									
W157 c W57	"									
W158 c W58	"									

c = corresponds with

APPENDIX III

SUMMARY OF WATER QUALITY NUTRIENT AND METAL DATA FOR THE FIVE FINGER ISLAND MARINE MUNICIPAL OUTFALL

APPENDIX III

TABLE 1 NUTRIENT DATA Adapted from Waters (1976a, 1976b)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source

AMMONIA (ppm)

DATA SOURCE:		WATERS 1976a				WATERS 1976a				WATERS 1976b			
		PRE-OPERATION March - September 1974				POST-OPERATION March - June 1975				POST-TREATMENT March - September 1974			
SAMPLING STATION	DEPTH* (m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0	8	0.053	< 0.020	0.110	4	0.003	< 0.001	0.006	18	0.005	< 0.001	0.026
S2	0	8	0.046	0.020	0.100	4	0.004	0.002	0.005	12	0.003	< 0.001	0.005
S3	0	8	0.049	< 0.020	0.090	4	0.003	< 0.001	0.005	13	0.003	< 0.001	0.012
S4	0	8	0.050	0.020	0.110	4	0.003	< 0.001	0.007	13	0.003	< 0.001	0.009
S5	0	8	0.046	0.020	0.150	4	0.004	0.003	0.006	13	0.003	< 0.001	0.007
S6	0	8	0.044	< 0.020	0.100	4	0.003	0.001	0.006	13	0.004	< 0.001	0.015
S7	0	8	0.049	< 0.020	0.150	4	0.004	0.001	0.007	13	0.004	< 0.001	0.011
S8	0	8	0.078	< 0.020	0.200	4	0.002	< 0.001	0.005	13	0.004	< 0.001	0.020
All	0	64	0.052	< 0.020	0.150	32	0.003	< 0.001	0.007	103	0.004	< 0.001	0.026
NITRITE (ppm)													
S1	0	8	0.006	ND	0.021	5	0.003	0.002	0.004	14	0.002	< 0.001	0.004
S2	0	8	0.006	ND	0.020	5	0.003	0.001	0.005	14	0.002	< 0.001	0.006
S3	0	8	0.006	ND	0.018	5	0.003	0.002	0.005	14	0.002	< 0.001	0.007
S4	0	8	0.006	ND	0.025	5	0.004	0.002	0.005	14	0.003	< 0.001	0.007
S5	0	8	0.005	ND	0.017	5	0.003	0.001	0.005	14	0.002	< 0.001	0.007
S6	0	8	0.005	< 0.020	0.015	5	0.003	0.002	0.005	14	0.002	< 0.001	0.007
S7	0	8	0.008	ND	0.022	5	0.003	0.002	0.005	14	0.002	< 0.001	0.006
S8	0	8	0.011	ND	0.042	5	0.003	0.001	0.005	14	0.002	< 0.001	0.006
All		64	0.007	ND	0.042	40	0.003	0.001	0.005	112	0.002	< 0.001	0.007

Continued...

APPENDIX III

TABLE 1 NUTRIENT DATA Adapted from Waters (1976a, 1976b)

Maximum, Minimum and Mean Values of Nutrient Data Recorded by Sampling Station and Data Source (Continued)

NITRATE (ppm)

DATA SOURCE:		WATERS 1976a				WATERS 1976a				WATERS 1976b			
		PRE-OPERATION				POST-OPERATION				POST-TREATMENT			
SAMPLING	DEPTH*	March - September 1974				March - June 1975				March - September 1974			
STATION	(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0	8	0.268	0.110	0.530	5	0.184	0.008	0.364	14	0.180	0.002	0.357
S2	0	8	0.295	0.140	0.500	5	0.181	0.002	0.364	14	0.182	0.002	0.392
S3	0	8	0.246	0.090	0.530	5	0.169	0.003	0.367	-	-	-	-
S4	0	8	0.294	0.140	0.620	5	0.169	0.003	0.366	-	-	-	-
S5	0	8	0.279	0.100	0.630	5	0.187	0.009	0.364	14	0.178	0.002	0.354
S6	0	8	0.275	0.040	0.460	5	0.172	0.003	0.367	14	0.195	< 0.001	0.369
S7	0	8	0.279	0.140	0.560	5	0.163	0.004	0.366	14	0.188	0.002	0.378
S8	0	8	0.355	0.160	0.680	5	0.177	0.003	0.346	14	0.187	0.002	0.360
All	0	64	0.286	0.040	0.680	40	0.175	0.002	0.367	84	0.185	< 0.001	0.378
							PHOSPHATE (ppm)						
S1	0	8	0.100	ND	0.215	5	0.046	0.007	0.073	14	0.038	0.003	0.071
S2	0	8	0.115	ND	0.218	5	0.047	0.010	0.073	14	0.036	0.0	0.064
S3	0	8	0.120	ND	0.215	5	0.043	0.009	0.011	14	0.035	0.004	0.061
S4	0	8	0.119	ND	0.218	5	0.044	0.010	0.070	14	0.037	0.003	0.061
S5	0	8	0.111	ND	0.206	5	0.046	0.060	0.072	14	0.036	0.003	0.061
S6	0	8	0.121	ND	0.211	5	0.047	0.010	0.073	14	0.037	0.004	0.062
S7	0	8	0.121	ND	0.215	5	0.045	0.010	0.071	14	0.037	0.003	0.065
S8	0	8	0.107	ND	0.218	5	0.048	0.011	0.068	14	0.037	0.003	0.065
All		64	0.114	ND	0.218	40	0.046	0.007	0.073	112	0.037	0.0	0.071

APPENDIX III
TABLE 2 NUTRIENT DATA Adapted from Packman (1977) and Pomeroy and Packman (1981)
Maximum, Minimum and Mean Values of Nutrient Data Recorded by Data Source

NITRITE (mg/l)

DEPTH	August 1975				August 1977				April 1978				November 1980			
(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
0	8	< 0.010	< 0.010	< 0.010	5	0.005	< 0.005	0.006	5	< 0.005	< 0.005	< 0.005	5	0.007	0.006	0.007
2	1	< 0.010	< 0.010	< 0.010	5	0.005	< 0.005	0.006	5	< 0.005	< 0.005	< 0.005	5	0.006	0.005	0.006
5	1	< 0.010	< 0.010	< 0.010	5	0.005	< 0.005	0.005	5	< 0.005	< 0.005	< 0.005	5	0.007	0.005	0.009
10	1	< 0.010	< 0.010	< 0.010	6	0.005	< 0.005	0.006	5	< 0.005	< 0.005	< 0.005	5	0.007	0.006	0.008
25	1	0.150	0.150	0.150	5	< 0.005	< 0.005	< 0.005	5	< 0.005	< 0.005	< 0.005	4	0.005	0.005	0.005
45									1	< 0.005	< 0.005	< 0.005				
50	1	0.300	0.300	0.300	5	< 0.005	< 0.005	< 0.005	4	< 0.005	< 0.005	< 0.005	2	0.005	0.005	0.005
60									2	< 0.005	< 0.005	< 0.005	3	0.005	0.005	0.005
65					1	< 0.006	< 0.006	< 0.006								
80	1	0.330	0.330	0.330												
100					3	< 0.005	< 0.005	< 0.005	1	< 0.005	< 0.005	< 0.005				
140													1	0.005	0.005	0.005
150					2	< 0.005	< 0.005	< 0.005								
All	14	0.117	0.010	0.330	36	< 0.005	< 0.005	< 0.005	33	< 0.005	< 0.005	< 0.005	30	0.006	0.005	0.009
								TOTAL PHOSPHATE (mg/l)								
0	8	0.020	0.020	0.020					5	0.066	0.063	0.069	5	0.052	0.049	0.055
2	1	0.020	0.020	0.202					5	0.066	0.063	0.072	5	0.051	0.051	0.0523
5	1	0.030	0.030	0.030					5	0.068	0.064	0.081	5	0.056	0.054	0.059
10	1	0.050	0.050	0.050					5	0.069	0.066	0.075	5	0.062	0.054	0.067
25	1	0.080	0.080	0.080					5	0.075	0.071	0.079	4	0.066	0.060	0.076
45									1	0.083	0.083	0.083				
50	1	0.020	0.020	0.020					4	0.080	0.077	0.083	2	0.068	0.067	0.069
60									2	0.086	0.085	0.087	3	0.069	0.066	0.071
65																
80	1	0.080	0.080	0.080												
100									1	0.078	0.078	0.078				
140													1	0.069	0.069	0.069
150																
All	14	0.043	0.020	0.080					33	0.075	0.063	0.087	30	0.055	0.049	0.076
Data Source	PACKMAN 1977				POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981			

Continued...

APPENDIX III NUTRIENT DATA Adapted from Packman (1977) and Pomeroy and Packman (1981)

TABLE 2 Maximum, Minimum and Mean Values of Nutrient Data Recorded by Data Source (Continued)

ORTHOPHOSPHATE (mg/l)

DEPTH (m)	August 1977				November 1980			
	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
0	5	0.058	0.054	0.064	5	0.053	0.049	0.054
2	5	0.060	0.057	0.065	5	0.053	0.050	0.055
5	5	0.064	0.059	0.069	5	0.055	0.053	0.061
10	5	0.062	0.060	0.065	5	0.064	0.057	0.067
25	5	0.058	0.039	0.066	4	0.067	0.061	0.078
45								
50	5	0.063	0.049	0.072	2	0.069	0.069	0.070
60					3	0.071	0.069	0.073
65	1	0.076	0.076	0.076				
80								
100	3	0.070	0.067	0.074				
140					1	0.074	0.074	0.074
150	2	0.071	0.068	0.075				
All	36	0.065	0.039	0.076	30	0.063	0.049	0.078
Data Source	POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981			

APPENDIX III
TABLE 2 NUTRIENT DATA Adapted from Packman (1977) and Pomeroy and Packman (1981)
Maximum, Minimum and Mean Values of Nutrient Data Recorded by Data Source
(Continued)

AMMONIA (mg/l)

DEPTH (m)	August 1975				August 1977				April 1978				November 1980			
	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
0	8	< 0.005	< 0.005	0.01	5	< 0.01	< 0.01	< 0.01	5	0.010	0.008	0.012	5	0.010	0.009	0.011
2	1	< 0.005			5	< 0.01	< 0.01	< 0.01	5	0.010	0.008	0.012	5	0.016	0.009	0.028
5	1	< 0.005			5	< 0.01	< 0.01	< 0.01	5	0.011	0.008	0.015	5	0.015	0.006	0.022
10	1	< 0.005			5	< 0.01	< 0.01	< 0.01	5	0.008	0.005	0.011	5	0.013	< 0.005	0.024
25	1	0.014			5	< 0.01	< 0.01	< 0.01	5	0.008	< 0.005	0.010	4	0.009	< 0.005	0.024
45									1	0.005	0.005	0.005				
50	1	< 0.005			5	< 0.01	< 0.01	< 0.01	4	0.008	< 0.005	0.011	2	0.022	0.018	0.026
60									2	0.008	0.006	0.009	3	0.055	< 0.005	0.007
65					1	< 0.01	< 0.01	< 0.01								
80	1	< 0.005														
100					3	< 0.01	< 0.01	< 0.01	1	< 0.005	< 0.005	< 0.005				
140													1	0.019		
150					2	< 0.01	< 0.01	< 0.01								
All	14	< 0.005	< 0.005	0.01	36	< 0.01	< 0.01	< 0.01	33	0.008	< 0.005	0.015	30	0.019	< 0.005	0.028
Data Source	PACKMAN 1977				POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981			

NITRATE (mg/l)

DEPTH (m)	August 1975				August 1977				April 1978				November 1980			
	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
0	8	< 0.005	< 0.005	< 0.005	5	0.304	0.244	0.390	5	0.276	0.261	0.284	5	0.218	0.198	0.236
2	1	< 0.005	< 0.005	< 0.005	5	0.321	0.267	0.405	5	0.282	0.267	0.289	5	0.212	0.192	0.219
5	1	< 0.005	< 0.005	< 0.005	5	0.315	0.300	0.325	5	0.289	0.271	0.331	5	0.223	0.190	0.258
10	1	< 0.005	< 0.005	< 0.005	5	0.342	0.325	0.365	5	0.295	0.271	0.341	5	0.273	0.225	0.299
25	1	< 0.005	< 0.005	< 0.005	5	0.363	0.340	0.385	5	0.325	0.315	0.340	4	0.300	0.253	0.390
45									1	0.380	0.380	0.380				
50	1	< 0.005	< 0.005	< 0.005	5	0.388	0.360	0.405	4	0.374	0.365	0.380	2	0.296	0.286	0.305
60									2	0.383	0.375	0.390	3	0.294	0.282	0.315
65					1	0.395	0.395	0.395								
80	1	< 0.005	< 0.005	< 0.005												
100									3	0.378	0.335	0.405				
140													1	0.312	0.312	0.312
150					2	0.380	0.370	0.390								
All	14	< 0.005	< 0.005	< 0.005	36		0.244	0.405	33	0.354	0.261	0.390	30	0.266	0.190	0.390
Data Source	PACKMAN 1977				POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981				POMEROY & PACKMAN 1981			

Continued...

APPENDIX III

TABLE 3 WATER QUALITY METAL DATA Adapted from Waters (1976a, 1976b)

Pre-, Post-Operation and Post-Treatment Values of Trace Metal Data Recorded According to Sampling Station and Data Source

MERCURY (ppm)

DATA SOURCE:		WATERS 1976a				WATERS 1976a				WATERS 1976a			
		PRE-OPERATION				POST-OPERATION				POST-TREATMENT			
		March - September 1974				March - June 1975				July 1975 - July 1976			
SAMPLING STATION	DEPTH (m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0	8	0.10	< 0.05	0.30	2	< 0.05	< 0.05	< 0.05	5	0.09	0.05	0.28
S2	0	8	0.08	< 0.05	0.20	1	< 0.05	< 0.05	< 0.05				
S3	0	8	0.07	< 0.05	0.10	1	< 0.05	< 0.05	< 0.05				
S4	0	8	0.06	< 0.05	0.10	1	< 0.05	< 0.05	< 0.05				
S5	0	8	0.08	< 0.05	0.10	1	< 0.05	< 0.05	< 0.05				
S6	0	8	0.08	< 0.05	0.15	1	< 0.05	< 0.05	< 0.05				
S7	0	8	0.05	< 0.05	0.10	1	< 0.05	< 0.05	< 0.05				
S8	0	8	0.08	< 0.05	0.15	2	< 0.05	< 0.05	< 0.05	5	0.05	0.02	0.05
All	0	64	0.08	< 0.05	0.30	10	< 0.05	< 0.05	< 0.05	10	0.07	0.02	0.28

LEAD (ppb)

SAMPLING STATION	DEPTH (m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0	8	3.50	< 1.00	11.00	2	5.00	1.00	10.00	5	4.80	1.00	13.00
S2	0	8	5.75	< 1.00	17.00	1	1.00	1.00	1.00				
S3	0	8	5.25	< 1.00	15.00	1	1.00	1.00	1.00				
S4	0	8	4.75	< 1.00	16.00	1	2.00	2.00	2.00				
S5	0	8	3.13	< 1.00	13.00	1	< 1.00	< 1.00	< 1.00				
S6	0	8	3.38	< 1.00	13.00	1	1.00	1.00	1.00				
S7	0	8	4.00	< 1.00	13.00	1	< 1.00	< 1.00	< 1.00				
S8	0	8	3.75	< 1.00	14.00	2	6.00	3.00	9.00	5	4.40	1.00	11.00
All		64	4.19	< 1.00	17.00	10	2.25	1.00	10.00	10	4.60	1.00	13.00

Continued...

APPENDIX III

TABLE 3 WATER QUALITY METAL DATA Adapted from Waters (1976a, 1976b)

Pre-, Post-Operation and Post-Treatment Values of Trace Metal Data Recorded According to Sampling Station (Continued)

ZINC (ppb)

DATA SOURCE:		WATERS 1976a				WATERS 1976a				WATERS 1976a			
		PRE-OPERATION March - September 1974				POST-OPERATION March - June 1975				POST-TREATMENT July 1975 - July 1976			
SAMPLING STATION	DEPTH (m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
S1	0	8	16.75	4.00	38.00	2	14.00	9.00	19.00	5	6.40	1.00	16.00
S2	0	8	16.38	4.00	55.00	1	7.00	7.00	7.00				
S3	0	8	9.63	2.00	21.00	1	7.00	7.00	7.00				
S4	0	8	7.63	2.00	18.00	1	5.00	5.00	5.00				
S5	0	8	7.63	2.00	18.00	1	4.00	4.00	4.00				
S6	0	8	10.00	2.00	25.00	1	12.00	12.00	12.00				
S7	0	8	7.38	1.00	20.00	1	4.00	4.00	4.00				
S8	0	8	6.63	1.00	17.00	2	15.50	14.00	17.00	5	21.00	< 1.00	88.00
All	0	64	10.25	1.00	55.00	10	8.56	4.00	19.00	10	13.70	< 1.00	88.00
						COPPER (ppb)							
S1	0	8	5.50	2.00	10.00	2	6.50	1.00	12.00	5	4.00	< 1.00	6.00
S2	0	8	3.00	< 1.00	6.00	1	1.00	1.00	1.00				
S3	0	8	2.75	< 1.00	5.00	1	2.00	2.00	2.00				
S4	0	8	1.88	< 1.00	5.00	1	3.00	3.00	3.00				
S5	0	8	3.50	1.00	11.00	1	< 1.00	< 1.00	< 1.00				
S6	0	8	2.63	1.00	6.00	1	2.00	2.00	2.00				
S7	0	8	2.00	< 1.00	6.00	1	1.00	1.00	1.00				
S8	0	8	1.75	< 1.00	4.00	1	5.00	5.00	5.00	5	3.60	1.00	7.00
All		64	2.87	< 1.00	11.00	10	2.69	1.00	12.00	10	3.80	< 1.00	7.00

APPENDIX IV

WATER QUALITY NUTRIENT DATA AND SUMMARY STATISTICS FOR MARINE MUNICIPAL OUTFALLS

APPENDIX IV

TABLE 1 MACAULAY POINT: NUTRIENT DATA AND SUMMARY STATISTICS

Source: EQUIS

OUTFALL	SITE NO.	DEPTH (m)	DISS NO_3^- (mg/l)							TOTAL NO_3^- (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
W1	150000	0	42	.126	.383	.306	.0581	.0091	.299	35	.174	.398	.320	.0497	.0085	.316	1970 - 1979
W3	150001	0	42	.083	.388	.298	.066	.010	.288	36	.181	.397	.314	.052	.009	.309	"
W4	150002	0	42	.199	.383	.306	.053	.008	.302	36	.169	.393	.316	.060	.0085	.311	"
W2	150003	0															
		all	52	.128	.388	.303	.059	.008	.296	38	.179	.391	.318	.046	.008	.314	"
		3.99	1		.362												
		25	1		.332												
		50	1		.304												
W5	150004	0	43	.133	.379	.300	.063	.0097	.292	36	.177	.401	.315	.051	.0086	.311	1970 - 1979
W6	150005	0	43	.134	.383	.295	.065	.0100	.287	32	.157	.385	.311	.054	.0096	.306	"
W7	150006	0	43	.208	.383	.306	.053	.0082	.301	36	.184	.389	.317	.047	.0079	.316	"
W8	150007	0	43	.132	.382	.296	.064	.0099	.288	36	.180	.394	.319	.050	.0085	.314	"
W9	150008	0	43	.104	.378	.287	.072	.0110	.276	36	.169	.388	.309	.066	.0085	.303	"
S1	150009	0	43	.065	.38	.267	.084	.0130	.250	36	.111	.398	.281	.077	.0131	.269	"
S2	150010	0	43	.045	.383	.280	.081	.0125	.262	36	.168	.403	.304	.060	.010	.298	"
S3	150011	0	43	.111	.384	.292	.066	.0102	.283	36	.119	.393	.303	.062	.010	.295	"
S4	150012	0	42	.023	.407	.259	.0954	.0149	.230	34	.051	.379	.281	.085	.015	.262	"
J1	150018	0								4	.215	.340	.290	.053	.031	.286	1971 - 1979
		3.99	1		.297												
		25	1		.311												
		50	1		.317												
		75	1		.421												
		all	11	.231	.421	.316	.0546	.0173	.312								
J2	150019	0								2	.244	.321	.283	.054	.054	.290	1971 - 1979
		3.99	1		.294												
		25	1		.281												
		50	1		.383												
		75	1		.365												
		100	1		.283												
		all	12	.205	.428	.312	.0674	.0203	.305								
WO	155050	0								13		.38	.320	.051	.014	.315	1972 - 1978

Continued...

APPENDIX IV
TABLE 1 MACAULAY POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH (m)	DISS NH$_3$ (mg/l)							DISS. NO$_2^-$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
W1	150000	0	26	.0052	.0844	.01785	.01569	.00314	.0142	96	.0012	.00869	.00363	.00136	.00014	.00337	1970 - 1979
W3	150001	0	26	.0038	.0305	.01472	.00813	.00163	.01258	97	.0012	.006	.0035	.0011	.001	.0033	"
W4	150002	0	26	.004	.034	.0151	.0082	.0016	.0130	97	.0012	.00956	.0035	.0014	.0001	.0032	"
W2	150003	0	31	.004	.0375	.0154	.0088	.0016	.0130								"
		all								113	.001	.01511	.00363	.0016	.00015	.00333	
		3.99								1	.00408						
		25								1	.00506						
		50								1	.00454						
W5	150004	0	26	.0051	.0331	.0147	.0079	.00158	.0128	98	.0012	.00827	.00352	.00129	.00013	.00327	1970 - 1979
W6	150005	0	28	.0045	.0356	.0155	.0074	.0014	.0140	96	.0011	.01016	.00351	.00139	.00014	.00322	"
W7	150006	0	26	.004	.0361	.0145	.0083	.0017	.0123	98	.0011	.0058	.0034	.0012	.0001	.0031	"
W8	150007	0	26	.0043	.0344	.0146	.0084	.0017	.0124	98	< .0002	.0065	.0035	.0013	.0001	.0031	"
W9	150008	0	26	.0041	.0336	.0142	.0078	.0016	.0123	98	.0013	.0061	.0038	.0012	.0001	.0036	"
S1	150009	0	28	.0086	.0411	.0192	.0092	.0018	.0173	100	.0015	.00847	.0038	.0012	.0001	.0033	"
S2	150010	0	28	.0065	.0327	.0161	.0070	.0013	.0147	100	.0014	.00652	.0037	.0011	.0001	.0035	"
S3	150011	0	28	.0013	..1482	.0280	.0358	.0069	.0175	100	.0015	.01579	.0044	.0023	.0002	.0039	"
S4	150012	0	28	.0067	.0449	.0183	.0082	.0016	.0169	97	.0018	.0063	.0038	.0010	.0001	.0037	"
J1	150018	0	5	.0083	.0379	.0188	.0115	.0057	.0165								1971 - 1979
		3.99								1		.00332					
		25								1		.00355					
		50								1		.00332					
		75								1		.00376					
		all								18	.0012	.005	.0038	.0008	.0002	.0037	
J2	150019	0	5	.0065	.0413	.0201	.0134	.0067	.0167								1971 - 1979
		3.99								1		.0043					
		25								1		.00379					
		50								1		.00343					
		75								1		.00365					
		100								1		.00214					
		all								17	.197	.0061	.0040	.0011	.0003	.0039	
W0	156050	0	6		.0278	.0202	.0062	.0028	.0193	19		.00552	.00337	.0011	.0003	.0032	1972 - 1978

Continued...

APPENDIX IV

TABLE 1 MACAULAY POINT: NUTRIENT DATA AND SUMMARY STATISTICS

Source: EQUIS

(Continued)

OUTFALL	SITE NO.	DEPTH (m)	DISS PO$_4$ (mg/l)							DISS. PO$_4$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
W1	150000	0	19	.054	.0713	.0621	.0055	.0013	.0619	46	.028	.076	.061	.011	.0016	.0660	1970 - 1979
W3	150001	0	19	.0502	.0712	.0613	.0057	.0013	.0610	46	.026	.079	.0605	.0118	.0018	.0591	"
W4	150002	0	19	.0542	.0707	.0618	.0055	.0013	.0616	46	.026	.077	.0608	.0110	.0016	.0596	"
W2	150003	0	22	.0526	.0717	.0613	.0054	.0012	.0611	50	.026	.076	.0607	.0106	.0015	.0596	"
		all															
		3.99															
		25															
		50															
W5	150004	0	19	.059	.0714	.0616	.0056	.0013	.0614	46	.026	.077	.060	.0113	.017	.0591	1970 - 1979
W6	150005	0	21	.053	.0715	.0621	.0059	.0013	.0618	42	.028	.078	.060	.0114	.0018	.0586	"
W7	150006	0	19	.0534	.0711	.0617	.0056	.0013	.0614	46	.027	.078	.061	.011	.0016	.0595	"
W8	150007	0	19	.0528	.0715	.0616	.0059	.0014	.0613	46	.029	.075	.061	.010	.0015	.060	"
W9	150008	0	19	.0401	.0706	.0608	.0071	.0017	.0603	46	.026	.077	.060	.011	.0016	.059	"
S1	150009	0	21	.0229	.0712	.0581	.0121	.0027	.0565	46	.024	.078	.057	.013	.0019	.055	"
S2	150010	0	21	.0606	.0712	.0614	.0066	.0015	.0611	46	.022	.075	.059	.012	.0018	.058	"
S3	150011	0	21	.0416	.0888	.0624	.0096	.0021	.0617	46	.027	.095	.062	.012	.0018	.061	"
S4	150012	0	21	.0241	.0711	.0585	.0120	.0027	.0569	44	.022	.077	.060	.012	.0018	.059	"
J1	150018	0	3	.0515	.0587	.0551	.0036	.0025	.0550	6	.045	.066	.057	.008	.0038	.057	1971 - 1979
		3.99															
		25															
		50															
		75															
		all															
J2	150019	0	3	.0544	.0609	.0573	.0033	.0023	.0573	4	.045	.065	.0548	.009	.0050	.054	1971 - 1979
		3.99															
		25															
		50															
		75															
		100															
		all															
W0	158060	0	6		.068	.0595	.0052	.0023	.0593	13		.08	.062	.0139	.0040	.060	1972 - 1978

APPENDIX IV

TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS

Source: EQUIS

OUTFALL	SITE NO.	DEPTH (m)	DISS NH$_3$ (mg/l)							TOTAL NH$_3$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S6	153017	0	28	.0103	1.8819	.2844	.4714	.0907	.1209	5	.02	15.00	3.1020	6.6517	3.3259	.2518	1971 - 1979
S59	153018	0	28	.0057	.0496	.0187	.0095	.0018	.0166	5	< .01	.03	.0160	.0090	.0045	.0143	1975 - 1981
W30	153019	0	26	.0025	.0373	.0155	.0092	.0018	.0127								1971 - 1979
S5	153020	0	28	.0063	.0408	.0178	.0093	.0018	.0159								"
W151	153021	0	14	.0384	1.0606	.2502	.3082	.0866	.1536								"

OUTFALL	SITE NO.	DEPTH (m)	DISS NO$_3^-$ (mg/l)							TOTAL NO$_3^-$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S6	153017	0	35	.0800	.5400	.3061	.0886	.0152	.2824	29	.1780	.3910	.3065	.0678	.0109	.3007	1971 - 1979
S59	153018	0	10	.2700	.4300	.3370	.0613	.0204	.3322								1975 - 1981
W30	153019	0	24	.2240	.3800	.3134	.0479	.0099	.3086	33	.1800	.3910	.3211	.0499	.0088	.3168	1971 - 1979
S5	153020	0	24	.1560	.3750	.3005	.0522	.0109	.2952	30	.1570	.3900	.3075	.0560	.0111	.3010	"
W151	153021	0	14	.0029	.0075	.0048	.0016	.0004	.0046								"

OUTFALL	SITE NO.	DEPTH (m)	DISS NO$_2^-$ (mg/l)							TOTAL NO$_2^-$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S6	153017	0	71	.0025	.0290	.0084	.0054	.0006	.0071	28	.0015	.0100	.0046	.0020	.0004	.0042	1971 - 1979
S59	153018	0	16	.0028	.0130	.0064	.0027	.0007	.0060	28	.0011	.0057	.0035	.0013	.0003	.0032	1975 - 1981
W30	153019	0	61	.0012	.0068	.0033	.0012	.0002	.0031	28	.0010	.0058	.0035	.0014	.0002	.0031	1971 - 1979
S6	153020	0	60	.0017	.0068	.0035	.0011	.0001	.0033	28	.0013	.0065	.0035	.0012	.0002	.0033	"

Continued...

APPENDIX IV
TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH (m)	TOTAL N ORG. (mg/l)							N KJEL (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S6	153017	0	4	.04	12.00	3.52	5.7261	3.3060	.4887	6	.15	27.00	4.9783	10.812	4.8353	.6876	1971 - 1979
S59	153018	0	4	.01	.1	.0500	.0392	.0226	.0366	6	.03	.1	.0583	.0248	.0111	.0541	1975 - 1981

OUTFALL	SITE NO.	DEPTH (m)	DISS PO$_4$ (mg/l)							TOTAL PO$_4$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S6	153017	0	44	.0431	3.1600	.2540	.4751	.7245	.1502	9	.2490	4.4000	1.0197	1.3062	.4618	.6567	1971 - 1979
S59	153018	0	44	.0518	.1850	.0671	.0202	.0031	.0663	9	.0620	.2590	.1068	.0664	.0235	.0941	1975 - 1981
W10	153019	0	32	.0333	.0717	.0610	.0086	.0015	.0603								1971 - 1979
S5	153020	0	34	.0366	.0710	.0607	.0086	.0015	.0601								"
W151	153021	0	14	.0595	.2404	.1182	.0578	.0160	.1068								"

OUTFALL	SITE NO.	DEPTH (m)	TOTAL PO$_4$ ORT							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S6	153017	0	30	.0270	.4130	.1381	.0809	.0150	.117	1971 - 1979
W10	153019	0	33	.0270	.0750	.0612	.0109	.0019	.0560	1971 - 1979
S5	153020	0	30	.0250	.0790	.0601	.0123	.0023	.0586	"

Continued...

APPENDIX IV
TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH (m)	DISS PO$_4$ (mg/l)							TOTAL PO$_4$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the . Mean	Geom. Mean	
S60	153000	0	44	.049	.922	.270	.255	.039	.179	9	.07		.080	.516	.182	.276	1975 - 1979
S61	153001	0	43	.046	.075	.062	.007	.001	.062	9	.068		.073	.005	.002	.073	"
W51	153002	0		.072													1975 - 1979
		3.99		.064													
		25		.064													
		50		.065													
		all	67	.0442	.072	.062	.005	.0006	.061	6	.066	.072	.070	.002	.001	.069	
W52	153003	0								2	.066	.07	.068		(min. .066)		1975 - 1979
		3.99		.063													
		25		.065													
		50		.088													
		all	62	.0509	.0726	.061	.005	.0006	.061								
W53	153004	0								4	.069	.073	.072	.002	.001	.071	1975 - 1979
		3.98	8		.063												
		25	8		.063												
		50	8		.088												
		all	65	.0374	.072	.061	.006	.0007	.061								
W54	153005	0															1975 - 1979
		3.99	8		.063												
		25	8		.064												
		50	8		.069												
		all	59	.0436	.0707	.061	.005	.0007	.061								
W55	153006	0															1975 - 1979
		3.99	8		.064												
		25	8	.065													
		50	8	.066													
		all	60	.0398	.0714	.061	.005	.0007	.061								
W56	153007	0	39	.0402	.073	.062	.006	.0009	.061	7	.064	.075	.069	.004	.002	.069	1975 - 1979
W57	153008	0	38	.043	.071	.062	.006	.001	.062	6	.065	.072	.069	.003	.001	.070	"
W58	153009	0	39	.038	.0709	.061	.007	.001	.061	7	.066	.072	.070	.002	.0008	.070	"

APPENDIX IV
TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH (m)	TOTAL N ORG (mg/l)							TOTAL N KJEL (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S60	153000	0	4	.02	3.79	.97	1.88	1.09	.10	6	.02	4	.80	1.6	.70	.2	1975 - 1979
S61	153001	0	3	.01	.03	.02	.011	.008	.014	5	ˉ .01	.09	.032	.034	.02	.02	"
W51	153002	0															1975 - 1979
		3.99															
		25															
		50															
		all	2	.01	.06	.035	.035	.035	.024	4	.01	.08	.048	.030	.017	.037	
W52	153003	0	1	.01	.01					2	.01	.02	.015	(min. ˉ .01)			1975 - 1979
		3.99															
		25															
		50															
		all															
W53	153004	0	1	.01	.01	.01				2	.01	.08	.045	(min. .01)			1975 - 1979
		3.99															
		25															
		50															
		all															
W56	153007	0	2	.01	.03					4	ˉ .01	.03	.015	.01	.006	.013	1975 - 1979
W57	153008	0	2	ˉ .01	.01					4	ˉ .01	.01	.01				"
W58	153009	0	2	.01	.15	.08				4	ˉ .01	.15	.07				"

Continued...

APPENDIX IV
TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH (m)	DISS NO_2^- (mg/l)							TOTAL NO_2^- (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S60	153000	0	16	.0035	.026	.011	.018	.002	.009	28	.0012	.177	.127	.032	.006	.006	1975 - 1979
S61	153001	0	16	.0022	.009	.006	.002	.001	.006	27	.0012	.0056	.003	.001	.0003	.003	"
W51	153002	0										.0057					1975 - 1979
		3.99										.0052					
		25										.0052					
		50										.0052					
		all	23	.0029	.007	.006	.001	.0003	.005	44	.0012	.0057	.004	.001	.0002	.004	
W52	153003	0								44	.0011	.0085	.004	.001	.0002	.004	1975 - 1979
		3.99	8		.005												
		25	8		.006												
		50	8		.006												
		all	18	.0029	.006	.004	.001	.0003	.004								
W53	153004	0						1975 - 1979									
		3.99	4		.006					4		.006					
		25	4		.006					4		.005					
		50	4		.006					4		.005					
		all	21	.0029	.007	.005	.002	.0003	.005	44	.0011	.0056	.004	.001	.0002	.004	
W54	153005	0															1975 - 1979
		3.99	4		.006					4		.006					
		25	4		.006					4		.006					
		50	4		.005					4		.006					
		all	16	.0028	.0058	.004	.001	.0003	.004	43	.0011	.0057	.004	.001	.0002	.004	
W55	153006	0															1975 - 1979
		3.99	4		.005					4		.005					
		25	4		.005					4	.005						
		50	4		.005					4	.005						
		all	16	.0029	.0055	.004	.001	.0002	.004	44	.0011	.0056	.0038	.0013	.0002	.0036	
W56	153007	0	11	.003	.008	.006	.002	.0005	.006	28	.0011	.0056	.0034	.0013	.0002	.0031	1975 - 1979
W57	153008	0	11	.0031	.007	.006	.001	.0005	.006	27	.0011	.0054	.0033	.0013	.0002	.0030	"
W54	153009	0	11	.003	.008	.006	.002	.0005	.006	28	.0011	.0054	.0034	.0013	.0003	.0031	"

Continued...

APPENDIX IV
TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH (m)	DISS. NO_3^- (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom.	
S60	153000	0	10	.12	.5	.328	.110	.037	.308	1975 - 1979
S61	153001	0	10	.27	.4	.33	.051	.017	.326	"
W51	153002	0								1975 - 1979
		3.99								
		25								
		50								
		all	7	.30	.39	.339	.031	.337		
W52	153003	0	2	.34	.39	.365	.035	.035	.36	1975 - 1979
		3.99								
		25								
		50								
		all								
W53	153004	0	5	.32	.36	.34	.022	.011	.335	1975 - 1979
		3.99								
		25								
		50								
		all								
W54	153005	0								1975 - 1979
		3.99								
		25								
		50								
		all								
W55	153006	0								1975 - 1979
		3.99								
		25								
		50								
		all								
W56	153007	0	7	.32	.39	.34	.028	.012	.339	1975 - 1979
W54	153008	0	7	.31	.39	.34	.028	.012	.339	1975 - 1979
W55	153009	0	7	.31	.39	.34	.027	.011	.341	1975 - 1979

Continued...

APPENDIX IV
TABLE 2 CLOVER POINT: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS
(Continued)

OUTFALL	SITE NO.	DEPTH	DISS NH_3 (mg/l)							TOTAL NH_3 (mg/l)							SAMPLING PERIOD
		(m)	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
S60	153000	0	28	.0114	3.722	.976	1.128	.217	.400	5	.01	.01	.028	.024	.012	.020	1975 - 1979
S61	153001	0	27	.0035	.0443	.019	.009	.002	.016	5	< .01	.06	.028	.025	.012	.020	"
W51	153002	0			.037												1975 - 1979
		3.99			.0308												
		25			.0326												
		50			.0334												
		all	54	.0043	.037	.019	.008	.001	.017	3	.02	.02	.013	.006	.004	.013	"
W52	153003	0								2	< .01	< .01	.01	.0	.0	.01	1975 - 1979
		3.99	8		.033												
		25	8		.031												
		50	8		.031												
		all	54	.0038	.036	.019	.008	.001	.017								
W53	153004	0								1	.01	.01	.01				1975 - 1979
		3.99	8		.067												
		25	8		.038												
		50	8		.032												-
		all	54	.0039	.0676	.020	.011	.001	.017								
W54	153005	0															1975 - 1979
		3.99	8		.031												
		25	8		.033												
		50	8		.032												
		all	53	.0041	.0338	.019	.008	.001	.017								
W55	153006	0															1975 - 1979
		3.99	8		.029												
		25	8		.036												
		50	8		.034												
		all	54	.0044	.0365	.019	.009	.001	.017								
W56	153007	0	26	.0048	.0366	.016	.008	.002	.014	3	< .01	< .01	< .01				1975 - 1979
W57	153008	0	25	.0042	.0274	.014	.008	.002	.012	3	< .01	< .01	< .01				"
W58	153009	0	26	.0039	.0357	.015	.009	.002	.012	3	< .01	< .01	< .01				"

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS

Reference: Vassos, 1982a Vol. II.

SITE	1973	1974	1975	1976	1977	1978	1979
			MEAN NO_3^- BY SITE AND YEAR (PPB AS NITROGEN)				
W0	320.25	292.00	350.50	-	352.30	308.68	-
W1	316.50	307.12	323.50	330.20	312.94	317.85	321.60
W2	312.45	307.87	323.75	324.45	304.45	315.90	313.49
W3	304.30	305.00	315.87	326.50	308.21	313.45	317.53
W4	309.20	303.87	319.25	327.30	313.89	320.57	317.50
W5	305.20	204.75	320.37	327.20	312.44	318.49	320.39
W6	311.67	295.86	307.86	323.89	300.20	315.50	321.12
W7	314.00	308.12	320.50	325.50	310.34	318.41	318.21
W8	311.70	308.37	322.62	330.50	309.64	315.14	317.89
W9	311.80	300.37	309.62	312.10	307.80	206.45	319.70
S1	277.50	265.12	280.50	294.80	277.92	282.96	280.50
S2	290.60	296.62	311.37	315.40	295.40	310.85	312.14
S3	298.50	281.75	305.62	319.50	307.13	303.35	313.36
S4	285.44	242.14	287.50	298.60	269.31	272.94	287.71
J1	319.50	-	-	261.00	269.50	291.50	280.60
J2	321.00	-	-	244.00	241.00	290.90	267.40
W10	-	-	-	325.62	309.45	319.29	328.22
W151	-	-	-	320.08	316.26	313.26	329.60
W152	-	-	-	330.70	321.52	316.91	324.50
W153	-	-	-	326.90	312.44	313.86	325.82
W154	-	-	-	329.08	311.85	313.12	324.92
W155	-	-	-	326.10	313.52	313.09	332.55
W156	-	-	-	324.70	313.56	317.79	329.98
W157	-	-	-	322.68	317.98	319.47	330.87
W158	-	-	-	326.52	315.08	316.92	331.08
S5	-	-	-	319.40	303.87	300.84	323.50
S6	-	-	-	300.48	300.78	309.42	325.79
S175	-	-	-	327.00	322.03	314.72	327.75
S178	-	-	-	307.48	314.25	309.63	328.29
S180	-	-	-	312.02	309.93	315.16	329.16

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NO_3^- 95% UPPER CONFIDENCE LIMITS (PPB AS NITROGEN)							
W0	345.91	379.23	725.33	-	352.30	332.49	-
W1	339.35	357.22	373.50	365.24	353.86	337.23	364.58
W2	335.30	356.32	371.47	354.15	336.37	331.62	352.23
W3	335.04	351.20	370.68	361.51	353.39	333.49	364.79
W4	335.34	354.59	372.82	359.93	351.92	340.33	360.39
W5	334.99	352.77	370.70	362.80	352.83	336.58	362.93
W6	340.16	362.96	364.65	361.85	347.74	336.24	353.63
W7	336.22	354.36	371.68	358.08	348.97	338.12	363.00
W8	379.73	356.10	375.00	366.23	350.80	334.39	362.76
W9	339.97	350.65	366.69	358.32	350.68	339.25	362.42
S1	322.57	338.96	355.74	350.87	338.08	322.54	356.31
S2	332.14	347.60	370.79	355.29	350.03	332.68	351.37
S3	330.07	350.93	366.51	356.13	345.76	335.68	352.79
S4	341.63	358.12	358.56	341.85	329.85	322.95	363.21
J1	579.96	-	-	845.44	529.96	475.77	280.60
J2	321.00	-	-	244.00	698.40	447.14	267.40
W10	-	-	-	363.50	357.18	338.52	364.49
W151	-	-	-	358.27	350.07	330.03	368.03
W152	-	-	-	369.22	353.01	335.35	362.85
W153	-	-	-	366.71	354.79	329.39	368.83
W154	-	-	-	366.08	352.31	329.93	364.19
W155	-	-	-	364.05	356.13	329.02	369.21
W156	-	-	-	365.46	353.97	336.79	367.43
W157	-	-	-	365.93	356.06	341.15	370.00
W158	-	-	-	361.58	356.93	336.03	363.30
S5	-	-	-	371.02	345.50	329.83	352.34
S6	-	-	-	356.01	348.51	333.31	353.83
S175	-	-	-	367.07	348.79	334.24	357.50
S178	-	-	-	356.33	359.31	341.35	363.89
S180	-	-	-	366.71	349.06	341.69	358.48

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS

Reference: Vassos, 1982a Vol. II.

(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NO_3^- 95% LOWER CONFIDENCE LIMITS (AS NITROGEN)							
W0	294.59	204.77	0.0	-	352.30	284.87	-
W1	293.65	257.02	273.50	295.16	272.02	298.47	278.62
W2	289.60	259.42	276.03	294.75	272.53	300.18	274.75
W3	273.56	258.80	261.06	291.49	263.03	293.41	270.27
W4	283.06	253.15	265.68	294.67	275.86	300.81	274.61
W5	275.41	256.73	270.04	291.60	272.05	300.40	277.85
W6	283.18	228.76	251.07	285.93	252.66	294.88	288.61
W7	291.78	261.88	269.32	292.92	271.71	298.70	273.42
W8	283.67	260.64	270.24	294.77	268.48	295.89	273.02
W9	283.63	250.09	252.55	265.88	264.97	273.65	276.98
S1	232.43	191.28	205.26	238.73	217.76	243.38	204.69
S2	249.06	245.64	251.95	275.51	240.77	289.02	272.91
S3	266.93	212.57	244.73	282.87	268.50	271.02	273.93
S4	229.25	126.16	216.44	255.35	208.77	222.93	212.21
J1	59.04	-	-	0.0	9.04	107.23	280.60
J2	321.00	-	-	244.00	0.0	134.66	267.40
W10	-	-	-	287.74	261.72	300.06	291.95
W151	-	-	-	281.89	282.45	296.49	291.17
W152	-	-	-	292.18	290.02	298.47	286.15
W153	-	-	-	287.09	270.09	298.33	282.81
W154	-	-	-	292.08	271.39	296.31	285.65
W155	-	-	-	288.15	270.91	297.16	295.89
W156	-	-	-	283.94	273.15	298.79	292.53
W157	-	-	-	279.43	279.90	297.79	291.74
W158	-	-	-	291.46	273.23	297.81	298.86
S5	-	-	-	267.78	262.24	271.85	294.66
S6	-	-	-	244.95	253.05	285.53	297.75
S175	-	-	-	286.93	295.27	295.20	298.00
S178	-	-	-	258.63	269.19	277.91	292.69
S180	-	-	-	257.33	270.80	288.63	299.84

Continued...

APPENDIX IV
TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NO_3^- NUMBER OF SAMPLING DATES							
W0	4	5	2	-	1	5	-
W1	10	8	8	10	10	10	7
W2	11	8	8	11	12	12	8
W3	10	8	8	10	10	10	7
W4	10	8	8	10	10	10	7
W5	10	8	8	10	10	10	7
W6	9	7	7	9	10	10	9
W7	10	8	8	10	10	10	7
W8	10	8	8	10	10	10	7
W9	10	8	8	10	10	10	7
S1	10	8	8	10	10	10	9
S2	10	8	8	10	10	10	9
S3	10	8	8	10	10	10	9
S4	9	7	8	10	10	10	9
J1	2	-	-	2	2	2	1
J2	1	-	-	1	2	2	1
W10	-	-	-	5	10	14	6
W151	-	-	-	5	10	10	6
W152	-	-	-	5	10	14	6
W153	-	-	-	5	10	14	6
W154	-	-	-	5	10	13	6
W155	-	-	-	5	10	14	6
W156	-	-	-	5	10	10	6
W157	-	-	-	5	10	9	6
W158	-	-	-	5	10	10	6
S5	-	-	-	5	10	10	8
S6	-	-	-	5	10	10	8
S175	-	-	-	5	10	10	8
S178	-	-	-	5	10	10	8
S180	-	-	-	5	10	9	8

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
MEAN NO_2^- BY SITE AND YEAR (PPR AS NITROGEN)							
W0	3.07	3.72	2.65	-	4.40	3.46	-
W1	3.21	3.52	3.13	3.34	3.94	3.56	3.60
W2	3.18	3.37	3.08	3.43	3.94	3.55	3.40
W3	3.26	3.49	3.18	3.39	3.91	3.41	3.39
W4	3.28	3.30	3.10	3.30	3.86	3.45	3.37
W5	3.24	3.32	3.09	3.30	3.94	3.36	3.37
W6	3.34	3.28	3.14	3.34	3.81	3.38	3.44
W7	3.11	3.25	2.09	3.29	3.85	3.36	3.40
W8	3.25	3.30	3.11	3.26	3.99	3.43	3.43
W9	3.27	3.32	3.14	3.40	3.94	3.34	3.47
S1	3.50	3.73	3.56	3.80	4.17	3.63	3.72
S2	3.43	3.54	3.39	3.68	4.02	3.53	3.69
S3	3.64	3.41	3.35	3.74	4.08	3.47	3.60
S4	3.60	3.42	3.40	3.94	4.27	3.61	3.46
J1	3.14	-	-	4.05	4.25	4.65	4.00
J2	3.70	-	-	4.41	4.95	5.25	3.90
W10	-	-	-	3.48	3.80	3.34	3.66
W151	-	-	-	3.44	3.66	3.83	3.70
W152	-	-	-	3.42	3.61	3.66	3.56
W153	-	-	-	3.44	3.63	3.80	3.57
W154	-	-	-	3.46	3.56	3.69	3.57
W155	-	-	-	3.44	3.59	3.66	3.60
W156	-	-	-	3.50	3.66	3.28	3.59
W157	-	-	-	3.46	3.65	3.17	3.60
W158	-	-	-	3.50	3.62	3.27	3.53
S5	-	-	-	3.42	3.88	3.37	3.57
S6	-	-	-	4.52	5.35	4.22	4.00
S175	-	-	-	3.54	3.83	3.40	3.59
S178	-	-	-	5.14	6.36	6.56	4.89
S180	-	-	-	3.64	3.74	3.23	3.71

Continued...

APPENDIX IV
TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NO_2^- 95% UPPER CONFIDENCE LIMITS (PPB AS NITROGEN)							
W0	5.71	4.50	18.10	-	4.40	4.44	-
W1	4.09	4.16	4.09	4.21	5.04	4.53	4.82
W2	3.88	4.10	4.06	4.27	4.80	4.43	4.37
W3	4.11	4.20	4.08	4.26	4.97	4.33	4.50
W4	4.17	4.03	4.16	4.24	4.93	4.27	4.55
W5	4.18	4.12	4.00	4.23	5.01	4.31	4.55
W6	4.19	4.22	4.34	4.44	4.86	4.32	4.29
W7	4.00	4.07	4.10	4.23	4.91	4.32	4.56
W8	4.20	4.05	4.18	4.18	5.15	4.37	4.71
W9	4.09	4.10	4.24	4.27	4.98	4.27	4.67
S1	4.32	4.41	4.26	4.63	5.05	4.55	4.65
S2	4.21	4.16	4.27	4.52	5.04	4.47	4.57
S3	4.45	4.13	4.33	4.63	5.12	4.28	4.52
S4	4.35	4.14	4.18	4.68	5.01	4.43	4.39
J1	4.76	-	-	5.85	11.26	9.05	4.00
J2	3.70	-	-	4.41	14.47	16.03	3.90
W10	-	-	-	5.03	4.90	4.28	5.09
W151	-	-	-	5.15	4.75	4.62	5.05
W152	-	-	-	5.03	4.67	4.44	4.86
W153	-	-	-	5.04	4.67	4.61	4.85
W154	-	-	-	5.25	4.53	4.55	4.97
W155	-	-	-	5.03	4.61	4.42	4.93
W156	-	-	-	5.15	4.67	4.20	4.83
W157	-	-	-	5.11	4.69	4.21	4.88
W158	-	-	-	5.26	4.66	4.18	4.82
S5	-	-	-	4.84	4.77	4.24	4.73
S6	-	-	-	6.42	7.40	4.76	4.98
S175	-	-	-	5.23	4.80	4.33	4.62
S178	-	-	-	9.10	7.89	9.44	5.91
S180	-	-	-	5.54	4.66	4.20	4.89

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NO_2^- 95% LOWER CONFIDENCE LIMITS (PPB AS NITROGEN)							
W0	0.43	2.94	0.0	-	4.40	2.48	-
W1	2.33	2.88	2.17	2.47	2.84	2.59	2.38
W2	2.48	2.64	2.10	2.59	3.08	2.67	2.43
W3	2.41	2.78	2.28	2.52	2.85	2.49	2.28
W4	2.39	2.57	2.04	2.36	2.79	2.63	2.19
W5	2.30	2.52	2.18	2.37	2.87	2.41	2.19
W6	2.49	2.34	1.94	2.24	2.76	2.44	2.59
W7	2.22	2.43	2.08	2.35	2.79	2.40	2.24
W8	2.30	2.55	2.04	2.34	2.83	2.49	2.15
W9	2.45	2.54	2.04	2.53	2.90	2.46	2.27
S1	2.68	3.05	2.86	2.97	3.29	2.71	2.79
S2	2.65	2.92	2.51	2.84	3.00	2.64	2.81
S3	2.83	2.69	2.37	2.85	3.04	2.66	2.68
S4	2.85	2.70	2.62	3.20	3.53	2.79	2.53
J1	1.52	-	-	2.25	0.0	0.25	4.00
J2	3.70	-	-	4.41	0.0	0.0	3.90
W10	-	-	-	1.93	2.70	2.40	2.23
W151	-	-	-	1.73	2.57	3.04	2.35
W152	-	-	-	1.81	2.55	2.88	2.26
W153	-	-	-	1.84	2.59	2.99	2.29
W154	-	-	-	1.67	2.59	2.83	2.17
W155	-	-	-	1.85	2.57	2.90	2.27
W156	-	-	-	1.85	2.65	2.36	2.35
W157	-	-	-	1.81	2.61	2.13	2.32
W158	-	-	-	1.74	2.58	2.36	2.24
S5	-	-	-	2.00	2.99	2.50	2.61
S6	-	-	-	2.62	3.30	3.68	3.02
S175	-	-	-	1.85	2.86	2.47	2.56
S178	-	-	-	1.18	4.83	3.68	3.87
S180	-	-	-	1.74	2.82	2.26	2.53

Continued...

APPENDIX IV
TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NO_2^- NUMBER OF SAMPLING DATES							
W0	4	5	2	-	1	5	-
W1	10	8	8	10	10	10	7
W2	12	8	8	11	12	12	8
W3	10	8	8	10	10	10	7
W4	10	8	8	10	10	10	7
W5	10	8	8	10	10	10	7
W6	9	7	7	9	10	10	9
W7	10	8	8	10	10	10	7
W8	10	8	8	10	10	10	7
W9	10	8	8	10	10	10	7
S1	10	8	8	10	10	10	9
S2	10	8	8	10	10	10	9
S3	10	8	8	10	10	10	9
S4	9	7	8	10	10	10	9
J1	2	-	-	2	2	2	1
J2	1	-	-	1	2	2	1
W10	-	-	-	5	10	10	7
W151	-	-	-	5	10	14	7
W152	-	-	-	5	10	14	7
W153	-	-	-	5	10	14	7
W154	-	-	-	5	10	13	7
W155	-	-	-	5	10	14	7
W156	-	-	-	5	10	10	7
W157	-	-	-	5	10	9	7
W158	-	-	-	5	10	10	7
S5	-	-	-	5	10	10	9
S6	-	-	-	5	10	10	9
S175	-	-	-	5	10	10	9
S178	-	-	-	5	10	10	9
S180	-	-	-	5	10	9	9

Continued...

APPEDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS

Reference: Vassos, 1982a Vol. II.

(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
MEAN NH_3 BY SITE AND YEAR (PPB AS NITROGEN)							
W0	-	-	-	-	10.50	22.18	-
W1	-	-	-	-	17.29	21.20	13.79
W2	-	-	-	-	10.28	20.88	14.02
W3	-	-	-	-	10.78	19.59	12.84
W4	-	-	-	-	10.42	20.57	13.43
W5	-	-	-	-	9.67	20.04	13.49
W6	-	-	-	-	12.48	20.16	13.34
W7	-	-	-	-	9.34	19.92	13.24
W8	-	-	-	-	10.99	19.58	12.20
W9	-	-	-	-	10.43	18.92	12.41
S1	-	-	-	-	15.43	24.22	17.26
S2	-	-	-	-	12.76	20.81	14.07
S3	-	-	-	-	46.13	25.43	12.67
S4	-	-	-	-	15.57	23.75	15.04
J1	-	-	-	-	13.15	28.00	11.80
J2	-	-	-	-	12.15	32.25	11.80
W10	-	-	-	-	11.52	19.65	14.57
W151	-	-	-	-	12.37	20.77	13.10
W152	-	-	-	-	11.16	21.11	13.90
W153	-	-	-	-	9.72	20.96	14.10
W154	-	-	-	-	11.48	19.61	13.70
W155	-	-	-	-	10.54	21.36	15.56
W156	-	-	-	-	12.44	20.00	15.50
W157	-	-	-	-	10.81	17.44	14.99
W158	-	-	-	-	10.66	19.50	13.66
S5	-	-	-	-	13.38	22.14	17.33
S6	-	-	-	-	642.79	143.54	82.61
S175	-	-	-	-	15.29	23.25	17.03
S178	-	-	-	-	1458.57	1076.75	380.73
S180	-	-	-	-	19.23	19.21	17.53

Continued...

APPENDIX IV
TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
				NH_3 95% UPPER CONFIDENCE LIMITS (PPB AS NITROGEN)			
W0	-	-	-	-	10.50	27.69	-
W1	-	-	-	-	36.76	27.00	19.12
W2	-	-	-	-	13.48	27.37	19.14
W3	-	-	-	-	16.07	25.82	18.05
W4	-	-	-	-	14.35	27.02	18.84
W5	-	-	-	-	12.51	26.51	18.63
W6	-	-	-	-	15.37	26.88	17.51
W7	-	-	-	-	12.52	26.89	18.57
W8	-	-	-	-	16.13	26.18	17.69
W9	-	-	-	-	13.78	25.71	17.81
S1	-	-	-	-	19.94	32.00	23.57
S2	-	-	-	-	15.82	26.75	18.04
S3	-	-	-	-	91.17	35.27	17.94
S4	-	-	-	-	19.94	30.82	18.84
J1	-	-	-	-	74.78	153.78	11.80
J2	-	-	-	-	83.94	147.25	11.80
W10	-	-	-	-	16.35	27.84	21.26
W151	-	-	-	-	17.24	26.66	18.21
W152	-	-	-	-	15.04	27.08	18.92
W153	-	-	-	-	12.68	26.62	19.20
W154	-	-	-	-	15.32	25.29	18.81
W155	-	-	-	-	14.24	27.21	24.06
W156	-	-	-	-	16.45	27.98	19.84
W157	-	-	-	-	14.14	24.99	21.94
W158	-	-	-	-	14.36	27.83	19.22
S5	-	-	-	-	16.85	20.82	23.15
S6	-	-	-	-	1196.86	214.41	131.94
S175	-	-	-	-	20.29	32.13	22.20
S178	-	-	-	-	2590.38	1852.09	654.80
S180	-	-	-	-	28.20	27.17	22.74

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

NH_3 95% LOWER CONFIDENCE LIMITS (PPB AS NITROGEN)

SITE	1973	1974	1975	1976	1977	1978	1979
W0	-	-	-	-	10.50	16.67	-
W1	-	-	-	-	0.0	15.40	8.46
W2	-	-	-	-	7.08	14.39	8.90
W3	-	-	-	-	5.49	13.36	7.63
W4	-	-	-	-	6.49	14.12	8.02
W5	-	-	-	-	6.83	13.57	8.35
W6	-	-	-	-	9.59	13.44	9.17
W7	-	-	-	-	6.16	12.95	7.91
W8	-	-	-	-	5.85	12.98	6.71
W9	-	-	-	-	7.08	12.13	7.01
S1	-	-	-	-	10.92	16.44	10.95
S2	-	-	-	-	9.70	14.87	10.10
S3	-	-	-	-	1.09	15.59	7.40
S4	-	-	-	-	11.20	16.68	11.24
J1	-	-	-	-	0.0	0.0	11.80
J2	-	-	-	-	0.0	0.0	11.80
W10	-	-	-	-	6.69	11.46	7.88
W151	-	-	-	-	7.50	14.88	7.99
W152	-	-	-	-	7.28	15.14	9.06
W153	-	-	-	-	6.76	15.30	9.00
W154	-	-	-	-	7.64	13.93	8.59
W155	-	-	-	-	6.84	15.51	7.06
W156	-	-	-	-	8.43	12.02	11.16
W157	-	-	-	-	7.48	9.89	8.04
W158	-	-	-	-	6.96	11.17	8.10
S5	-	-	-	-	9.91	13.46	11.51
S6	-	-	-	-	88.72	72.67	33.28
S175	-	-	-	-	10.29	14.37	11.86
S178	-	-	-	-	326.76	301.41	106.66
S180	-	-	-	-	10.44	11.25	12.32

Continued...

APPENDIX IV
TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
NH_3 NUMBER OF SAMPLING DATES							
W0	-	-	-	-	1	5	-
W1	-	-	-	-	9	10	7
W2	-	-	-	-	11	12	8
W3	-	-	-	-	9	10	7
W4	-	-	-	-	9	10	7
W5	-	-	-	-	9	10	7
W6	-	-	-	-	9	10	9
W7	-	-	-	-	9	10	7
W8	-	-	-	-	9	10	7
W9	-	-	-	-	9	10	7
S1	-	-	-	-	9	10	9
S2	-	-	-	-	9	10	9
S3	-	-	-	-	9	10	9
S4	-	-	-	-	9	10	9
J1	-	-	-	-	2	2	1
J2	-	-	-	-	2	2	1
W10	-	-	-	-	9	10	7
W151	-	-	-	-	9	14	7
W152	-	-	-	-	9	14	7
W153	-	-	-	-	9	14	7
W154	-	-	-	-	9	13	7
W155	-	-	-	-	9	14	7
W156	-	-	-	-	9	10	7
W157	-	-	-	-	9	9	7
W158	-	-	-	-	9	10	7
S5	-	-	-	-	9	10	9
S6	-	-	-	-	9	10	9
S175	-	-	-	-	9	10	9
S178	-	-	-	-	9	10	9
S180	-	-	-	-	9	9	9

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.

SITE	1973	1974	1975	1976	1977	1978	1979
			MEAN PHOSPHATE BY SITE AND YEAR (PPB AS PHOSPHOROUS)				
W0	64.50	53.20	67.50	-	68.00	57.74	-
W1	62.80	57.52	61.87	60.20	61.49	60.92	62.00
W2	62.00	57.00	62.25	60.40	60.38	60.49	60.99
W3	61.80	57.25	61.62	59.20	60.45	59.88	61.24
W4	61.80	57.50	61.75	60.00	61.40	61.03	60.94
W5	60.80	56.87	61.75	59.60	61.20	60.33	61.40
W6	61.67	56.29	59.68	60.33	59.76	60.46	62.47
W7	61.90	57.25	61.62	60.10	61.43	60.77	60.99
W8	61.30	58.37	61.75	62.10	61.19	60.62	60.91
W9	61.20	56.25	60.00	59.90	61.79	58.87	61.30
S1	57.80	53.62	57.12	57.20	57.14	56.68	56.99
S2	58.90	55.12	60.50	60.10	59.64	59.54	61.88
S3	61.00	56.75	63.00	65.40	66.36	59.32	62.03
S4	61.11	55.00	60.62	61.30	59.87	56.63	58.24
J1	65.50	-	-	52.50	55.00	55.10	55.00
J2	65.00	-	-	51.00	51.50	58.80	54.40
W10	-	-	-	60.26	60.37	61.49	61.89
W151	-	-	-	63.34	61.32	60.94	61.58
W152	-	-	-	64.08	62.17	60.91	60.98
W153	-	-	-	63.76	60.49	60.75	60.17
W154	-	-	-	62.82	60.73	60.75	60.68
W155	-	-	-	63.50	60.69	60.87	61.25
W156	-	-	-	63.26	61.20	61.50	61.93
W157	-	-	-	63.94	61.40	61.26	61.51
W158	-	-	-	60.74	61.13	61.33	61.84
S5	-	-	-	60.44	60.37	59.73	62.33
S6	-	-	-	208.56	205.48	90.64	89.17
S175	-	-	-	63.62	63.47	61.41	62.82
S178	-	-	-	195.42	351.42	265.18	178.78
S180	-	-	-	62.58	61.84	61.28	63.29

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.

SITE	1973	1974	1975	1976	1977	1978	1979
PHOSPHATE 95% UPPER CONFIDENCE LIMITS (PPB AS PHORPHOROUS)							
W0	84.18	73.50	137.40	-	68.00	62.05	-
W1	68.24	69.33	72.20	67.74	68.60	64.53	67.53
W2	67.67	68.85	72.67	68.03	65.67	63.61	66.16
W3	70.05	68.93	72.30	66.82	67.79	63.69	66.78
W4	68.94	69.47	72.06	67.62	67.69	64.47	66.71
W5	68.64	68.41	72.00	67.45	68.07	64.05	66.76
W6	69.48	69.25	71.67	69.16	67.77	64.22	67.44
W7	68.82	68.50	71.65	67.85	68.04	64.31	66.74
W8	68.32	69.12	71.58	67.15	68.01	64.23	67.32
W9	68.46	67.60	70.77	67.51	68.04	64.51	66.56
S1	67.18	65.98	70.35	65.71	66.17	63.50	68.52
S2	67.87	67.94	71.72	66.18	67.62	63.85	67.30
S3	68.75	68.10	73.76	74.53	75.48	65.17	67.15
S4	69.40	70.38	71.31	67.42	67.63	64.05	69.33
J1	71.88	-	-	147.83	118.52	100.83	55.00
J2	65.00	-	-	51.00	134.07	85.48	54.40
W10	-	-	-	76.68	68.47	64.52	66.94
W151	-	-	-	69.93	67.09	62.91	63.11
W152	-	-	-	71.09	66.84	62.99	62.70
W153	-	-	-	70.84	67.49	62.88	62.00
W154	-	-	-	68.26	66.9	62.81	62.17
W155	-	-	-	70.38	67.37	62.57	63.07
W156	-	-	-	70.58	67.75	64.73	67.66
W157	-	-	-	71.14	67.59	64.77	66.61
W158	-	-	-	77.35	68.03	64.63	66.57
S5	-	-	-	77.85	66.99	64.84	67.63
S6	-	-	-	359.63	333.03	112.05	109.23
S175	-	-	-	70.86	67.59	64.98	67.94
S178	-	-	-	455.82	598.78	424.26	307.35
S180	-	-	-	70.95	67.63	65.85	68.89

Continued...

APPENDIX IV

TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.

SITE	1973	1974	1975	1976	1977	1978	1979
PHOSPHATE 95% LOWER CONFIDENCE LIMITS (PPB AS PHOSPHOROUS)							
W0	44.82	32.90	0.0	-	68.00	53.43	-
W1	57.36	45.91	51.54	52.66	54.38	57.31	56.47
W2	56.33	45.15	51.38	52.77	55.09	57.37	55.82
W3	53.55	45.57	50.94	51.58	53.11	56.07	55.70
W4	54.66	45.53	51.44	52.38	55.11	57.59	55.17
W5	52.96	45.33	51.50	51.75	54.33	56.61	56.04
W6	53.86	43.33	48.05	51.50	51.75	56.70	57.50
W7	54.98	45.90	51.59	52.35	54.81	57.23	55.24
W8	54.28	47.62	51.92	57.05	54.37	57.01	54.50
W9	53.94	44.90	49.23	52.29	55.54	53.23	56.04
S1	48.42	41.26	43.89	48.69	48.11	49.86	45.46
S2	49.93	42.30	49.28	54.02	51.66	66.23	56.46
S3	53.25	45.40	52.24	56.27	57.24	53.47	56.91
S4	52.82	39.62	49.93	55.18	52.11	49.21	47.15
J1	59.12	-	-	0.0	0.0	9.37	55.00
J2	65.00	-	-	51.00	0.0	32.12	54.40
W10	-	-	-	43.84	52.27	58.46	56.84
W151	-	-	-	56.75	55.55	58.97	60.05
W152	-	-	-	57.07	57.50	58.83	59.26
W153	-	-	-	56.68	53.49	58.62	58.34
W154	-	-	-	57.38	54.47	58.69	59.19
W155	-	-	-	56.62	54.01	59.17	59.43
W156	-	-	-	55.94	54.65	58.27	56.20
W157	-	-	-	56.74	55.21	57.75	56.41
W158	-	-	-	44.13	54.23	58.03	57.11
S5	-	-	-	43.03	53.75	54.62	57.03
S6	-	-	-	57.49	77.93	69.23	69.11
S175	-	-	-	56.38	59.35	57.84	57.70
S178	-	-	-	0.0	104.06	106.10	50.21
S180	-	-	-	54.21	56.05	56.71	57.69

Continued...

APPEDIX IV
TABLE 3 MACAULAY POINT AND CLOVER POINT NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Vassos, 1982a Vol. II.
(Continued)

SITE	1973	1974	1975	1976	1977	1978	1979
PHOSPHATE NUMBER OF SAMPLING DATES							
W0	4	4	2	-	1	5	-
W1	10	8	8	10	10	10	7
W2	12	8	8	10	12	12	8
W3	10	8	8	10	10	10	7
W4	10	8	8	10	10	10	7
W5	10	8	8	10	10	10	7
W6	9	7	7	9	10	10	9
W7	10	8	8	10	10	10	7
W8	10	8	8	10	10	10	7
W9	10	8	8	10	10	10	7
S1	10	8	8	10	10	10	9
S2	10	8	8	10	10	10	9
S3	10	8	8	10	10	10	9
S4	9	7	8	10	10	10	9
J1	2	-	-	2	2	2	1
J2	1	-	-	1	2	2	1
W10	-	-	-	5	10	10	7
W151	-	-	-	5	10	26	19
W152	-	-	-	5	10	26	19
W153	-	-	-	5	10	26	19
W154	-	-	-	5	10	25	19
W155	-	-	-	5	10	26	19
W156	-	-	-	5	10	10	7
W157	-	-	-	5	10	9	7
W158	-	-	-	5	10	10	7
S5	-	-	-	5	10	10	9
S6	-	-	-	5	10	10	9
S175	-	-	-	5	10	10	9
S178	-	-	-	5	10	10	9
S180	-	-	-	5	10	9	9

APPENDIX IV
TABLE 4 SIDNEY: NUTRIENT DATA AND SUMMARY STATISTICS
Source: EQUIS

OUTFALL	SITE NO.	DEPTH (m)	DISS NH$_3$ (mg/l)							UNKNOWN NO$_3^-$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
M212	152743	0	6	.0086	.2065	.0698	.0863	.0386	.0329	2	.1512	.3060	.2286	.1095	.1095	.2151	
M211	152744	0	14	.0057	.0308	.0188	.0085	.0024	.0166	10	.1556	.3464	.2586	.0706	.0236	.2476	1973 - 1980
M213	152745	0	14	.0062	.0340	.0200	.0092	.0026	.0176	10	.1783	.3470	.2630	.0642	.0214	.2567	"
M210	152746	0	1	.0199	.0199	.0199			.0199	1	.3157	.3157				.3157	1978
M214	152747	0	5	.0080	.0275	.0163	.0086	.0043	.0145	2	.0965	.3120	.2043	.1524	.1524	.1736	1975 - 1978
M215	152748	0	8	.0071	.0654	.0265	.0177	.0067	.0219	8	.1854	.3503	.2675	.0644	.0243	.2607	1975 - 1980

OUTFALL	SITE NO.	DEPTH (m)	TOTAL NO$_3^-$ (mg/l)							DISS. NO$_2^-$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
M212	152743	0	13	.0050	.3810	.2505	.1094	.3158	.1898	11	.0007	.0078	.0037	.0018	.0006	.0033	
M211	152744	0	13	.0060	.3730	.2534	.1039	.0299	.1968	19	.0005	.0049	.0034	.0010	.0002	.0032	1973 - 1980
M213	152745	0	13	.0040	.3730	.2504	.1096	.0316	.1866	19	.0009	.0051	.0034	.0009	.0002	.0032	"
M210	152746	0								1	.0034	.0034	.0034			.0034	1978
M214	152747	0	8	.0020	.3750	.2458	.1365	.0516	.1414	10	.0007	.0053	.0031	.0012	.0004	.0028	1975 - 1978
M215	152748	0								8	.0025	.0051	.0036	.0008	.0003	.0036	1975 - 1980

OUTFALL	SITE NO.	DEPTH (m)	TOTAL NO$_2^-$ (mg/l)							DISS. PO$_4$ ORT (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
M212	152743	0	4	.0034	.3680	.1810	.2045	.1181	.0381	11	.0070	.0940	.0557	.0264	.0083	.0466	
M211	152744	0	4	.0043	.3810	.1869	.2099	.1212	.0402	19	.0050	.0730	.0548	.015	.0041	.0493	1973 - 1980
M213	152745	0	4	.0042	.3940	.1871	.2121	.1224	.0397	18	.0110	.0720	.0543	.0163	.0040	.0506	"
M210	152746	0								1	.0631	.0631				.0631	1978
M214	152747	0								10	.008	.0730	.0522	.0224	.0075	.0449	1975 - 1978
M215	152748	0								8	.0446	.0695	.0585	.0084	.0032	.0679	1978 - 1980

OUTFALL	SITE NO.	DEPTH (m)	TOTAL PO$_4$ (mg/l)							SAMPLING PERIOD
			No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	
M212	152743	0	4	.0430	.0560	.0520	.0061	.0035	.0517	
M211	152744	0	4	.0450	.0570	.0525	.0052	.0030	.0523	1973 - 1980
M213	152745	0	4	.0480	.0560	.0533	.0038	.0022	.0532	"

APPENDIX IV
TABLE 5 FRENCH CREEK: NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Pomeroy, 1982

DEPTH	AMMONIA (mg/l)											
	AUGUST 1977				APRIL 1978				NOVEMBER 1980			
(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
0	4	0.013	0.010	0.014	5	0.082	0.006	0.011	5	0.029	< 0.005	0.060
2	4	0.012	0.011	0.014	5	0.089	0.005	0.011	5	0.019	< 0.005	0.041
5	4	0.012	0.010	0.012	5	0.090	0.007	0.010	5	0.013	0.005	0.035
10	4	0.013	< 0.010	0.020	5	0.010	0.008	0.012	5	0.015	0.007	0.035
20					1	0.011	0.011	0.011				
25	4	0.011	< 0.010	0.013	4	0.011	0.008	0.014	5	0.012	< 0.005	0.019
45									1	0.007	0.007	0.007
50	4	< 0.010	< 0.010	< 0.010	4	< 0.005	< 0.005	< 0.005	3	0.019	< 0.005	0.040
60									3	0.008	< 0.005	0.011
65	1	< 0.010	< 0.010	< 0.010	1	< 0.005	< 0.005	< 0.005				
80	1	< 0.010	< 0.010	< 0.010	1	< 0.005	< 0.005	< 0.005				

DEPTH	NITRATE (mg/l)											
	AUGUST 1977				APRIL 1978				NOVEMBER 1980			
(m)	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.	No. of Values	Mean	Min.	Max.
0	5	0.176	0.122	0.210	5	0.238	0.189	0.299	5	0.271	0.245	0.305
2	5	0.176	0.132	0.200	5	0.247	0.191	0.302	5	0.272	0.259	0.292
5	5	0.196	0.152	0.210	6	0.254	0.228	0.306	5	0.275	0.257	0.312
10	5	0.281	0.242	0.315	5	0.275	0.259	0.301	6	0.277	0.228	0.309
20					1	0.300	0.300	0.300				
25	5	0.325	0.300	0.350	4	0.305	0.285	0.315	5	0.288	0.266	0.314
45									1	0.308	0.308	0.308
50	4	0.376	0.350	0.395	4	0.373	0.360	0.380	3	0.298	0.289	0.311
60									3	0.292	0.281	0.310
65	1	0.400	0.400	0.400	1	0.390	0.390	0.390				
80	1	0.410	0.410	0.410	1	0.390	0.390	0.390				

Continued...

APPENDIX IV
TABLE 5

FRENCH CREEK: NUTRIENT DATA AND SUMMARY STATISTICS
Reference: Pomeroy, 1982
(Continued)

DEPTH (m)	NITRITE (mg/l) AUGUST 1977 No. of Values	Mean	Min.	Max.	APRIL 1978 No. of Values	Mean	Min.	Max.	NOVEMBER 1980 No. of Values	Mean	Min.	Max.
0	5	0.006	0.006	0.006	5	< 0.005	< 0.005	< 0.005	5	0.005	< 0.005	0.006
2	5	0.006	0.006	0.006	5	< 0.005	< 0.005	< 0.005	6	0.006	< 0.005	0.008
5	5	0.006	0.006	0.006	5	< 0.005	< 0.005	< 0.005	5	0.005	< 0.005	0.006
10	5	0.006	0.006	0.006	6	< 0.005	< 0.005	< 0.005	5	< 0.005	< 0.005	< 0.005
20					1	< 0.005	< 0.005	< 0.005				
25	5	0.006	0.006	0.006	4	< 0.005	< 0.005	< 0.005	5	< 0.005	< 0.005	< 0.005
45									1	0.308	0.308	0.308
50	4	0.006	0.006	0.006	4	< 0.005	< 0.005	< 0.005	3	< 0.005	< 0.005	< 0.005
60									3	< 0.005	< 0.005	< 0.005
65	1	0.006	0.006	0.006	1	< 0.005	< 0.005	< 0.005				
80	1	0.006	0.006	0.006	1	< 0.005	< 0.005	< 0.005				

DEPTH (m)	ORTHO-PHOSPHATE (mg/l) AUGUST 1977 No. of Values	Mean	Min.	Max.	NOVEMBER 1980 No. of Values	Mean	Min.	Max.	TOTAL PHOSPHATE (mg/l) APRIL 1978 No. of Values	Mean	Min.	Max.	NOVEMBER 1980 No. of Values	Mean	Min.	Max.
0	5	0.046	0.037	0.054	5	0.062	0.055	0.068	5	0.071	0.061	0.085	5	0.049	0.036	0.060
2	5	0.045	0.039	0.051	5	0.060	0.050	0.065	5	0.071	0.065	0.086	5	0.055	0.050	0.060
5	5	0.049	0.043	0.054	5	0.060	0.053	0.070	5	0.067	0.064	0.070	5	0.052	0.047	0.059
10	5	0.063	0.057	0.069	5	0.065	0.063	0.069	5	0.069	0.067	0.071	5	0.057	0.051	0.063
20									1	0.071	0.071	0.071				
25	5	0.069	0.061	0.078	5	0.067	0.062	0.073	4	0.072	0.070	0.074	5		0.055	0.063
45					1	0.072	0.072	0.072					1	0.070	0.070	0.070
50	4	0.072	0.071	0.073	3	0.070	0.067	0.072					3	0.045	0.026	0.054
60					3	0.068	0.063	0.072					3	0.045	0.026	0.054
65	1	0.075	0.075	0.075					1	0.083	0.083	0.083				
80	1	0.080	0.080	0.080					1	0.085	0.085	0.085				

APPENDIX IV

TABLE 6 LIONS GATE: NUTRIENT DATA AND SUMMARY STATISTICS

Source: EQUIS

OUTFALL	SITE NO.	DEPTH (m)	TOTAL NH_3 (mg/l) No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	TOTAL NO_3^- (mg/l) No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	SAMPLING PERIOD
#3	301642	all	19	0.01	.0800	.0211	0.0235	.0055	.0151	16	.1500	.3800	.2806	.0835	.0215	.2677	1975 - 1979
#4	301643	0	5	0.01	.0500	.0180	.0179	.0089	.0138	4	.0700	.2600	0.13	.0898	.0519	.1112	1975 - 1978
WEST	301645	all	10	0.01	.0800	.0370	.0267	.0089	.0284	10	.1100	.4000	.2760	.1052	.0351	.2528	1979

OUTFALL	SITE NO.	DEPTH (m)	DISS. NO_2^- (mg/l) No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	TOTAL PO_4 (mg/l) No. of Values	Min.	Max.	Aver.	Stand. Dev.	St. Error of the Mean	Geom. Mean	SAMPLING PERIOD
#3	301642	all	18	.0050	.0080	.0064	.0092	.0002	.0063	7	.0250	7.1	1.0659	2.6653	1.0881	.0928	1975 - 1979
#4	301643	0	4	.0050	.0070	.0058	.0010	.0006	.0057	7	.0430	.9560	.1837	.3407	.1391	.0815	1975 - 1978
WEST	301645	all	10	.0050	.0080	.0068	.0010	.0003	.0067								1979